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CONTENTS

The Editor's Page 122

Clarifies Objectives of Drying Study 122

To Continue Warp Sizing Study 123

Discussion of Paper on Drying Problems in Other Industries 127

The Adsorption of Oxygen by Mercerized Cotton. D. J. Salley, *Fellow of the Textile Foundation* 133

Comparison of Three Methods for Determining the Breaking Strength of Cotton Fibres. Mary Anna Grimes..... 145

Abstracts 149

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The Editor's Page

THE research on warp sizing and sizing materials, which has been in progress at Massachusetts Institute of Technology since May, 1935, is to be continued for another year at least, the third year starting Jan. 1, 1937. The Textile Foundation has kindly renewed its grant for another year, and a majority of the co-operators in the financing have also renewed their subscriptions. The report of a meeting of co-operators, held at the Hotel Pennsylvania, New York, N. Y., Dec. 16, to hear recommendations of the administration committee and the director of the study will be found in this issue.

ONLY fourteen additional subscribers at $100 each, or a total of $1,400, are needed at this writing to complete the first year's financing of the research on textile drying. This project is being wholly financed by U. S. Institute for Textile Research, and a total of $5,000 must be subscribed by 50 co-operators before the administration committee (W. E. Emley, chairman, Alban Eavenson and H. DeW. Smith) can complete its organization, and recommend to the Research Council and the Executive Committee the place, director and personnel for the study. Those who may be hesitating to subscribe until the latter facts are decided should know that they are delaying unnecessarily the completion of the financing and the starting of research work. Co-operators will have the same opportunity to express their preferences that was given to co-operators in the warp sizing study. They should realize also that the number of mills and allied interests required to complete this financing is double the number which financed the warp sizing study, and that the number of contributing members of U. S. Institute who will qualify to receive the confidential progress reports of the drying project will be considerably over 100. Those who are coming in eventually for the latter can help most by coming in now and being listed among those who are making the study possible.

Clarifies Objectives of Drying Study

SINCE the presentation and discussion of the revised program for the textile drying study, at the research conference, Nov. 5, several suggestions for improvement or clarifying of the program's objectives have been received by the Committee in charge of the project. They welcome additional constructive suggestions. One of the valuable comments received by Dr. Smith of this committee, who was chairman of the research conference, is as follows:

"With reference to the program for the research on textile drying which was presented at our annual meeting, there are one or two comments which we would like to make. In the first place, we would emphasize the necessity of correctly wording the objectives of this program so that they may be better understood and appreciated by those whom you are attempting to interest in underwriting the financial part of the project.

"You did the right thing in your description of the program by simplifying the ideas expressed in the various items. For example, the objective in item B would be to determine the regain of the several types of fibre at different relative humidities, particularly at those high temperatures encountered during drying. Item C might be expressed as: How hot can a fibre be without damaging it as far as its physical properties and dyeing properties are concerned?

"Then, too, it might be advisable to express a third objective which should be represented as being included in the first year's program; something along these lines: What effect has the rate of drying from different moisture contents down to a given moisture equilibria on physical properties and dyeing properties of several fibres? Really, in this possibly there might be found the practical needs of the whole problem. While it is theoretically true that as long as a body still retains water, the temperature of that body cannot rise above a certain point in spite of the temperature of the surrounding air, yet, as a matter of fact, we feel that it is possible to get localized areas definitely overdried if the rate of air movement is not sufficiently uniform, or possibly if sufficiently high to cause localized case hardening. On the other side of the picture is the possibility of a too low rate of drying causing 'wicking' of whatever traces of water-soluble components, whether they be natural or applied finishes, that may be on the fibres. The practically important thing in drying, as well as in other handling of textiles, is that the operation must be done uniformly. If that is not the case, localized abnormalities, of course, would show up as defects of one sort or another. In practice it is these localized deviations from the mass of the product which probably cause us the greatest amount of trouble.

"We feel that decided emphasis should be placed on the observation of the uniformity of effect of various drying treatments as well as the recording of the extremes of difference which may be found."

To Continue Warp Sizing Study

AT a meeting of co-operators in U. S. Institute's research on warp sizing and sizing materials, held at Hotel Pennsylvania, New York, N. Y., Dec. 16, the administration committee for that study (Wright Bolton, *Chm.*, Dr. J. B. Quig and Dr. H. A. Neville) and Director W. E. Yelland explained its present status and their plans for its future. Chairman Bolton presided, and, after explaining that unexpected expenditures would render additional financing necessary, recommended that this be for a third year starting Jan. 1, 1937. He stated that the Textile Foundation, which co-operated with U. S. Institute on a 50–50 basis in the original financing, had been asked to continue on this basis for another year starting Jan. 1. Vice-president Alban Eavenson then announced that President Garvan had just telephoned him that the Textile Foundation had notified him that this grant had been authorized.

Following the reports presented by Chairman Bolton and Director Yelland there was extended discussion, the outcome of which was that all of the co-operators present either agreed to continue at least another year from Jan. 1, 1937, or to recommend such continuance to their principals.

Chairman Bolton's Report

Chairman Bolton's report was in large part as follows: Your committee held a meeting in New York City the week of Oct. 19 at which all members and Director Yelland were present; this was for the purpose of surveying work to date and that already planned, and for discussing ways and means by which the laboratory and mill work might be continued after Dec. 31, at which time contributed funds will have been seriously depleted. Your committee believes that results to date not only justify continuance of the study for another year, but that its continuance indefinitely would form a highly important service to the industry. We have the laboratory equipment and personnel and we have a mill that is willing to continue to co-operate. We have a director and assistants who are already well trained in the necessary laboratory technique, and who are now being trained in its practical application by mill experimental work. With the completion in the near future of the latter part of the rayon program your director should be able, in co-operation with practical mill men, to provide valuable advice for the improvement of viscose-type rayon sizing methods. This is the type of service that we are proposing to provide to co-operators in the textile drying study. It will be just as important a service in connection with the warp sizing study.

The study of viscose- and acetate-process rayon sizing may be completed by the end of the second year of this research, but even if the information developed should be the final word for these types of sizing and materials used at present, which is most unlikely, many problems requiring research would continue to develop as the result of production of new types of synthetic fibres and of new types of synthetic sizing materials. Furthermore, our study of starches and of their use as sizing materials is far from completion. Even if it were to be as far advanced at the end of the second year as the rayon sizing program, the industry would continue to be faced by new problems. Therefore, we believe that we are justified in suggesting that this study should be considered permanent, for several years at least, and that plans for such continuance should be developed.

Now, just a few words as to the results of this sizing research to date, not as chairman of your committee, but as the agent of a rayon weaving mill. I cannot say that there is a single result of the study to date which I have found to have direct practical application in the mill, but practical interpretation of certain of the results, and the indicated meaning of other results, have been of the greatest value, and worth far more than $200 which my company has contributed to this study thus far. But it is in its indirect results that the study has been of the greatest value to co-operators and to the whole industry. I refer to the fact that it has keyed up the manufacturers of sizing materials, machinery, and other supplies to the improving of their products. Not only have higher speed slashers resulted, but many other valuable improvements. Not only have several new synthetic sizing materials made their appearance, but I think it is fair to say that there has been a general improvement in the quality of sizing materials delivered during the past year. Furthermore, manufacturers have been made keenly alive to the possibilities of improving their sizing processes by the mere fact that this study has been deemed worthwhile by so representative an organization and a group of co-operators. Several mills, some of which are not yet financial co-opera-

tors in this study, have spent as much or more than we have in research work with satisfactory results, and the general improvement in sizing practice throughout the industry must be credited largely to the existence of this piece of research and the publicity given to it in the Trade Press.

Director Yelland's Report

Introduction: It is not my purpose to give a detailed account of the work done since the beginning of this project. Such information may be found in the confidential reports already printed and in those still to come. I intend rather to present a brief resume of the main lines of research, to summarize the results achieved so far and to outline further plans.

The field of warp sizing is large and extremely complicated and the problem may be approached from a number of angles. The first method of approach is to study the basic raw materials, which in this case are starch, gelatin, softeners, plasticizers, etc.

A second method of approach is through the mechanics of the process itself. This includes a study of such factors as (1) sizing temperature, (2) drying temperature, (3) viscosity of size solutions, (4) stretch given yarn during slashing.

A third method of approach is to study the effect of sizing on the yarn properties, that is, how the operation of sizing affects (1) breaking strength of yarn, (2) elongation of yarn at the breaking point, (3) cohesion, (4) stiffness.

Study of Materials: The first eight months of this research were spent under the direction of Dr. Katz in a study of starches. The effects of heating, stirring, and addition of various salts on 1% pastes of many types of starch were investigated, and the results given in the first three reports. While these results are as yet not directly applicable to mill problems, since more concentrated pastes are used in the mills, they form the necessary basis for any further work in this line.

Last January it was decided by the committee that more rapid progress would be made by limiting the field of study to the synthetic yarns, more especially 150 denier 40 filament bright viscose. The rest of this report refers to this type of yarn.

The materials studied were gelatins, sulphonated oils, and hygroscopic agents. It was not possible with the time, personnel and equipment at our disposal to undertake what might be termed "fundamental research" in this part of the field. Instead, a series of gelatins in actual mill use, and many recommended by producers for use in warp sizing were investigated as to: (1) moisture content, (2) ash, (3) water absorption, (4) pH, (5) viscosity and rate of change of viscosity at 60° C. (140° F.). In addition to these we investigated a number of synthetic sizes which are in extensive use. All of this work had the ultimate purpose in view of being able eventually to write specifications for materials. The results of this work are printed in part in a report which will soon be ready for distribution.

Study of Mechanics of Process of Slashing

(1) Drying Temperature.—This would come within the scope of the drying research which is being sponsored by U. S. Institute for Textile Research. Many of the results of that research will doubtless be directly applicable to warp sizing, so that there is no need for a duplication of

work. However, it has been found that when the slasher is stopped there is a tendency in many cases for the surface temperature of the cans to rise 10–20° F. Yarn allowed to dry on the cans under such conditions is markedly stiffer than the yarn dried under normal running conditions. Controls are being installed on the slasher used in the experiments and the actual drying temperatures measured by means of a surface pyrometer.

(2) Temperature of the size box is being maintained as near 140° F. as possible. It is desirable to keep the temperature as constant as possible, as an increase in temperature causes a decrease in viscosity, and a fall in temperature causes a rise in viscosity.

(3) The viscosity is important in that it is one of the factors which influence the amount of size taken up by the yarn and the distribution of the size on the yarn. If all other factors, such as speed, squeeze roll pressure, etc., are maintained constant, the lower the viscosity the less size the yarn tends to pick up, and the greater the tendency to penetration of the size between the filaments.

(4) In report No. 4 we have already shown how the stretch during slashing affects the residual elongation of the yarn at its breaking point.

Study of Effect of Sizing on Yarn Properties

(1) Effect on Breaking Strength.—The process of sizing usually increases the breaking strengths of viscose 6 to 14%. Some size manufacturers claim a much higher increase in breaking strength. This point may perhaps be overestimated, as measurements of loom tension show that in common types of weave the tension on a single viscose end (150 denier 40 filament) is much less than the breaking strength of the unsized end. Moreover, I have seen a viscose warp woven for demonstration purposes at a textile school without any size whatsoever. In this case warp breaks were always preceded by a separation and fraying of the filaments.

(2) It is possible to measure the cohesion of sized yarn, that is, the resistance to separation of filaments under abrasion, by means of a Duplan cohesion tester. However, the values do not necessarily correlate with the weaving properties of the yarn. Samples taken from warps being successfully woven in different mills had cohesion numbers as widely separated as 15 and 155. So that cohesion, at least as measured in this way, is not the whole story.

In determining the effect of the size on the yarn it is necessary to know the distribution of the size on the yarn. A technique has been developed in our laboratory which enables us to locate the gelatin on the yarn by means of photomicrography of cross-sections of yarn. This, added to the method already known for studying sections of starch-sized yarn treated with iodine, gives us a means of comparing the coating, and penetration powers of different types of sizes. It will now be possible to investigate the effect of size penetration and coating in relation to the weave room efficiency. After all, the final test of a size is its ability to give good weave room efficiency with an optimum ease of removal. The details of the technique for making these photomicrographs will be presented soon in a confidential report.

The project has reached a stage where studies in weave room efficiency can now go profitably hand in hand with a study of materials and methods as outlined, and much work will be devoted in future to the actual weaving and desizing of warps in the mill.

Discussion of Paper on Drying Problems in Other Industries

SO many inquiries have been received for the stenographic report of the discussion that followed the presentation at the research conference, held in connection with U. S. Institute's annual meeting, Nov. 5th, of the paper by John O. Ross, of the Ross Engineering Corp., that it has been decided to publish it in large part. The subject of Mr. Ross' paper was Some Drying Problems in Other Industries Than the Textile Industry (*Tex. Rsch.*, Dec. 1936, P. 60–65). Dr. H. DeW. Smith, vice-chairman of the Research Council, presided at this session. Before opening the discussion Dr. Smith stated that any speaker who did not wish to be reported stenographically would have that wish respected. Excepting for the elimination of duplications, and of certain portions that were not reported clearly, the discussion was as follows:

Mr. Robertson: I would like to ask if anyone has heard of a process of drying involving refrigeration of softening solutions so that the latter can be used in very much more concentrated form than is ordinarily the case; say with 10% of moisture instead of, as ordinarily, with 90%?

Mr. Ross: I have not heard of that in the paper industry.

Dr. Hunter: Mention was made of using circulating hot water where it was necessary to hold the surface at a given temperature. Is it limited to that particular use, or has it found use in wider ramifications?

Mr. Ross: It has been used quite extensively in England in plants as widely separated from the paper industry as chemical plants; the largest meat packing plant in England was using it for everything except one purpose, and that was removing the grease from hides; the automobile industry uses it for drying of lacquers—all their caustic washing. I also visited a perfume plant where they were using it for the evaporating and heating of very valuable ingredients. It is also used for nickel plating. But, as I said, in England there is only one really big bakelite company and they use it throughout their entire plant.

Chm. Smith: I notice that we have some of the manufacturers of textile drying machinery with us and I am wondering whether they can tell us which of the things mentioned by Mr. Ross are being applied in the textile industry. For instance, on the pre-drying and extraction of materials, I presume we have already explored that possibility pretty well with vacuum and centrifuge extractors, trying to get as much excess moisture out of the goods as possible before they enter the dryer. But I wonder whether that isn't a phase of the problem that could bear even more study. One that strikes very close to home with me is this question of conditioning the goods so that they leave the dryer with the right moisture. Mr. Ross points out that the paper consumers are glad to buy a certain amount of water, and pay for it, in the form of paper, because the paper with the water is better paper than if it is too dry. I know from personal experience among the people who make fabrics out of syn-

thetic fibres that they would be much happier if they were buying a little more water in the fabrics than they get back from the finishing plants. I think a crying need in the synthetic fabric industry is that the finishers should be equipped to deliver the goods in a thoroughly conditioned state, and not bone-dry or very dry as they come from the dryers today. Certainly the "hand" of the goods and sometimes the color and the general quality would be very much improved if more attention were paid to getting the goods out of the dryer with the right amount of moisture in them, rather than taking them down to extreme dryness.

I should like to ask whether any of the machinery manufacturers can tell us something about this temperature zoning and whether that has been pressed very far in relation to the drying of textile fibres. Mr. Buck, have you any comments to offer along that line? I think I remember some discussion about that last May. Can we dry our textiles at high temperatures at the beginning and then ease them down?

Mr. Buck: When you dry at high temperatures you get much more drying than you do at lower temperatures without any injury to the fabric, because a large water content has sufficient mass to absorb the heat transfer. It is only when the moisture gets down below or near the saturation point, probably around 30 to 33 or 35% in textiles, that you have to look out for trouble, because, with high temperatures, after you get below those moisture contents your heat does have effect on the fibre structure itself. But as long as water is present you can go up to 300 and 350° without any material effect on the fibre.

Within the past few weeks I was talking to a manufacturer in New England, where they had used an oil burner to get high temperatures on drying cotton goods. They found that, up to around 300 or 325°, they could get high speeds without any injury to the fabric. Then they pushed the temperatures up to close to 500° but they didn't get any better drying condition. In other words, somewhere between 300 and 325° is the optimum.

It may be of interest, in connection with high temperatures, to tell you that I know of one plant that is running a tenter frame on rayons and synthetic fibres, and using the products of combustion from an oil-burning household furnace and they are carrying temperatures up into their main supply duct of around 1000 and 1100°. But of course those temperatures are not applied to the fabric itself. A dilution takes place normally; the distance from the duct allows a reduction in temperature so that probably at one end they are getting temperatures of somewhere around 300 to 400°.

I also know that in drying jersey cloth glove silk fabrics, a few years ago they said they didn't want temperatures over 170 or 180°, but they couldn't get any drying spread at those temperatures. They put the temperatures up to 200 or 250° and the goods came out all right. In other words, drying is a proposition of temperature, speed and water content.

Chm. Smith: As I understand it, at a temperature of 300° in the dryer the fabric will not reach 300° as long as it is evaporating water.

Mr. Buck: Of course. At 300° and above dry temperature, you probably will not get over 108 or 110° wet bulb in the dryer. As long as there is water present your goods will probably not go over 115° F., and still you can get 300° dry bulb temperature. You get a high rate of evaporation.

Another point which Mr. Ross made, which these cotton men all know, is that where they have a set of dry cans at the head of the frame, with the wet goods in contact with the hot surface, it is a more rapid way of heat transfer, and it is known that probably 80% of your water is removed in a quarter or a fifth of the drying time. So you remove a large percentage of that water in the initial treatment. Then, another thing is that when it goes into the dryer it is probably 130 or 140°, so you eliminate that warming up process and you immediately start your evaporation when it hits the high temperature. I think that is a great factor. I think in some cases if you can increase the temperature and reduce the viscosity of your water, you will get more rapid evaporation.

On the question of conditioning on the delivery end in the machine itself, it is rather difficult to get a uniform air application and it is also difficult to get a uniform moisture content throughout the width of the fabric. Consequently, you must dry down below its regain point. I don't mean that you must carry it to a bone-dry condition, for that is harmful, but if you can dry below its regain point then you have a better chance to bring it back up and level out the moisture, because in giving up its water the material isn't so uniform as in picking it up again, and you have a better chance of control.

Chm. Smith: Thank you. Are there further questions or comments?

Mr. Gerard: Mr. Buck brought out the point that dry bulb temperatures do not at all mean cloth temperatures. I think we should always emphasize this differentiation. There seems to be a great deal of misunderstanding about dry bulb temperature and cloth temperature. I think we should also emphasize the fact that one very important factor in reducing cloth temperature far below dry bulb temperature is proper air velocity. That is one thing which I think has often been overlooked.

I might add, in connection with the point of reducing moisture content of the material before you send it to the dryer, that a recent development of the variable slot vacuum extractor has been in that direction. It has been found that most mills run a wide variety of weights and weaves of cloth over vacuum extractors with a fixed slot. We have found that by varying the width of the slot we can extract any given cloth to its optimum moisture content.

Chm. Smith: In connection with these high temperatures, last May the "popcorn" effect was emphasized, if you recall. What would happen to a fibre if it were heated so suddenly that the moisture didn't have time to diffuse out? In other words, here we are talking about a dryer in which even at high temperatures your water is evaporating at such a rate as to keep the fibre temperature below the boiling point.

I should like to ask whether that "popcorn" effect is real. Is it possible to heat a textile fibre so rapidly, either in air or on a can, that the internal temperature of the fibre exceeds the boiling point before the water can diffuse out and you actually get an explosive effect, or are we just talking about something that doesn't happen? Does anybody have any experience on that? This term "popcorn effect" was invented last May by one of our discussers and I thought it was very graphic.

Mr. Buck: I should like to start a discussion with Mr. Ross. In other words, I want his support. I should like to say that, in regard to a paper making fibre, it has been highly hydrated. Take a rag fibre or rag stock that has been beaten out in a beater. There is water hydration. That is, the water has gone inside of the cellulose structure. I believe that if you

isolated that fibre and subjected it suddenly to elevated temperature, with no appreciable free surface water, you would get this swelling and hardening of the surface and you would get a damaged fibre. The reason I address this to Mr. Ross is that he has had more experience with paper drying than any of us, and he has probably seen that in some of his high temperature work.

Mr. Ross: We haven't found that where the paper was very wet.

Mr. Buck: Oh no, not when it is wet.

Mr. Ross: I am not advocating high temperatures where you get down to a certain moisture content such as you speak of. But we took a paper that was supposed to have an absolute limit of 120°. That was the problem we were given when we went in there. They said, "You must not dry this at over 120°." We put 900° on it until it was heated up, and one of the superintendents in the mill said he could tell the difference. Really, there wasn't any difference.

You can take a wet sheet of paper and put it through an open flame. All you are doing is heating up; and, of course, on this rag content stock you introduce size, glue, etc. We have never made any attempt to do that, because it isn't that wet; it is only about 25% moisture content when you put the glue in. Therefore we have never tried it there. But the big problem has been to try to heat up this mass of goods.

I recall a case where for years a mill had been using 180° maximum, and I can't tell you how much space this mill took for dryers. They are now using 1000° until it is about 25 or 30% wet, and finishing it at about 180°.

Then there is this question that you brought up, Mr. Buck, about the difficulty of getting it out uniformly. It is difficult. But it can be done. We had that same problem in the paper business. Today they are running quite uniformly on widths even of 300 ins. They allow a leeway of about ½ of 1%.

Mr. Gerard: Mr. Chairman, it seems to me that this "popcorn effect" that you spoke about might hinge on the question of whether or not a case hardening effect occurs in rapid drying at the outset of the drying process. If you get an impervious skin on the outside, it is conceivable that the inside will heat up to a pressure which would diffuse the skin and give a "popcorn effect." Outside of that it hardly seems conceivable that you could get a "popcorn effect" by drying with air, since the heat transfer is from the outside toward the center, and you always have the outside core.

It might be interesting to note that there has been some work done on the pre-heating of materials by means of so-called "fever heat," in which the heat is generated on the inside and has to diffuse out. In that case you might expect a "popcorn effect."

Mr. Ross: We have found that high-frequency drying has a great many points like that where you bring out the heat from the inside; but we have found that you won't get the results if you haven't sufficient mass. We have even found that you have to heat the surrounding air, unless the mass of goods is sufficient to absorb enough electricity to give off sufficient heat to come through. Some of the automobile people are doing that. With certain parts it works beautifully. In connection with other parts that are too thin and without enough mass, they simply don't get it.

We have had this "popcorn effect" on other products, but only where we have put in steam superheated 700 or 800°, and then suddenly released the pressure. Of course, that is the principle in the case of masonite and things like that. They really explode the granules of pulp by that very process, just like puffed wheat. You release the pressure, after the pressure is in there, and that will do it.

Of course, I don't know anything about what might happen on a textile, but it doesn't seem to me it would happen unless, as you say, you get a case hardening effect. However, I doubt if you will get that when the material is very wet.

Chm. Smith: Inasmuch as I don't think we ever dry by pressure in the textile industry, I think probably that "popcorn effect" doesn't arise from that. We have always wondered whether it comes from can drying, and I think this case hardening is intimately mixed up with that. It seems to me that one thing this research project can do is to perhaps investigate that point by studying films instead of filaments. It ought to be possible to learn something about case hardening and perhaps about the so-called "popcorn effect." Also we ought to take a material of definite thickness and surface for our measurements and then see whether we can apply any of that information to filaments. Are there any further questions?

Mr. Borghetty: Recently we have had occasion to investigate that "popcorn effect." The only time you get it is when you cure resins—anti-crease resins and things like that. Otherwise you have a wet condition of the cloth, and you don't have to worry, and up to 290° at least you don't get any direct deterioration of the fabric. So I don't think we have to worry much about it.

Another point you brought up was can drying. During the May session it seemed that can drying was taboo. It wasn't mentioned at all, except probably on the side. Recently I have had occasion to see that you can can-dry materials, including rayon goods, providing you take this precaution: as the cloth comes down, you must not allow too many of the cans to show dry cloth. In other words, it should be steamed toward the last two or three cans. Then you don't get a dry bulb condition. One trouble about the dry can, of course, is that as the rayon dries it tends to come in. As you pull out you get an excessive stress on the fibres. So there ought to be some sort of compensation effect there.

Chm. Smith: Yes, probably by the size or motion of the cans.

Mr. Ross: Speaking about can dryers, we find that we get blisters on the paper. We discovered that one of the great causes of that is the trapping of moisture between the sheet and the can. That is, as the paper passes from one can to the other moisture will trap in between. That moisture is probably 170°. It traps in between the paper and the can and immediately becomes hot, and, especially if your drying cylinders are hot, you will create steam and cause a blister in the sheet. A lot of blisters that we used to blame the wet end of the machine for were found to be caused by that. So we have to remove the vapor as quickly as it forms on the paper machine today. We can't let it stay in the "pockets," as we call them. We have to get it out of there so it won't trap back in under the surface. It may be that that might cause some trouble in textiles. If they were porous enough, it shouldn't. But if they are fairly close you may get that same effect.

Mr. Nickerson: Mr. Chairman, it seems to me that one of the most important phases of this question is the actual means of measuring the phenomena which we are up against: temperature, humid vapor, pressure, moisture content. It seems to me it would be very helpful if those who have had experience in that, as these experiences are recited, could go into some detail as to methods of measurement. I should like to start by asking Mr. Ross how he would determine that his sheet of paper was 120° in a temperature of 1000°, and Mr. Buck how he would know the temperature of his fabrics in connection with high temperature drying.

Mr. Ross: We have simply taken it with surface contacts of Foxboro surface temperature indicators.

Mr. Nickerson: Within the dryer, as it is passing through the dryer?

Mr. Ross: Of course; you remember a paper machine is open. There has been considerable improvement in the control of moisture content of the sheet as it travels through. Of course, there have been all sorts of attempts made, such as radio control, where you use the sheet of paper like a condenser on a radio, varying the moisture and varying the amount that is transmitted through it. This radio control is in use in a big mill in London. It is in use in a mill in this country. They simply use it like a radio condenser.

One of the electric companies has experimented on transmitting electricity through the sheet of paper. The wetter the sheet of goods, the greater the transmitting ability of the sheet. They have tied that up to determine the moisture content of the sheet, because they don't like to tear out samples of the paper as it goes through the machine. When you do that, you end up with a broken sheet, and if they are running 1500 ft. a minute (which is getting to be the speed) they soon can get a lot of broken paper. That is one thing we are contending with: this continuous increase in speed. Ten years ago 500 ft. a minute was supposed to be our limit because that was the fastest a man could handle it. Now, however, they are running 1500 ft. a minute and they don't use human beings to handle it. (Laughter.)

Chm. Smith: I think we have some of the instrument people with us. Perhaps they would have something to say about instruments that are being developed at these stages. Mr. Hawkins, have you anything to add to the discussion?

Mr. Hawkins: We are fairly busy studying this problem. We have learned a great deal about it. We have an instrument that we have recently developed that is in contact with the goods and determines their moisture content. So far, we do not claim that it is the cure-all for all drying problems. We have tackled the simple drying problems, namely, tenter frame and slasher, and we have used it on rayon, acetate, and cotton. We have still quite a little way to go before we will make public announcement of it. But there are some men in the audience who have seen the instrument in operation. It definitely records, instantly, the moisture in the goods, because it is calibrated for the goods which that company produces.

Mr. Fonda: I should like to ask Mr. Ross if he has had any indications, in connection with these high preliminary temperatures in paper, of discoloration in white paper, a browning effect; or similarly, if anyone has seen any indications of greying in textile fabrics.

(*Continued on page 160*)

The Adsorption of Oxygen by Mercerized Cotton

By D. J. SALLEY *

Fellow of the Textile Foundation

Abstract

An investigation has been made of the take-up of oxygen by mercerized cotton at liquid air temperatures and in the range from 0° C. to 110° C. A rapid van der Waal's adsorption of the usual type was observed at liquid air temperatures. From 0° C. to 80°C. an adsorption proceeding at a slow rate was found, while at still higher temperatures, oxidation was observed to set in. The effect of the ash content of the material on the adsorption and on the oxidation was also studied.

Introduction

A RECENT PAPER on the adsorption of gases by cellulose called attention to the importance of such studies for problems arising in connection with the deterioration of textiles in the atmosphere.[1] Reiteration was made there of the general point so often brought out in regard to the heterogeneous reaction between a gas and a solid, namely, that adsorption of the gas molecule at the solid-gas interface must be the first step in such a reaction. For the oxidation of cellulose by oxygen, therefore, a study of the adsorption process is clearly indicated, with attention being paid to its velocity and extent, as well as to the effects of various external factors.

This paper reports experiments made on the adsorption of oxygen by mercerized cotton at temperatures ranging from — 180° C. (liquid air) to 110° C. The primary intent was to establish the facts characterizing the take-up of oxygen by cellulose over this wide temperature interval. Further, an attempt was made to settle the effect on the adsorption process of one external factor, that of the ash content (in particular of the iron content) of the sample.

Mercerized cotton was chosen for study, first, because previous work had indicated that this material generally adsorbed larger amounts of gas than ordinary cotton, and, secondly, because in those instances where the ash content of the sample was to be artificially increased, alkali was to be used to precipitate iron hydroxide on the sample previously impregnated with an iron solution.

* Dr. Salley, as a Senior Fellow of the Textile Foundation, worked in Princeton University under the direction of Professor Hugh S. Taylor.

Experimental

Apparatus.—As in the author's previous experiments on adsorption of gases by cellulose, the conventional apparatus described by Pease [2] was used. Evacuation of the system was achieved by means of a two-stage mercury vapor pump backed by a Cenco Hyvac oil pump. Temperatures were maintained by jacketing the adsorption vessel with suitable baths. Except at — 192° C., and 0° C. these were vapor baths consisting of large asbestos-wrapped, pyrex test tubes containing appropriate constant boiling liquids. This type of bath had the additional advantage of effectively shielding the adsorption bulb from light, thereby preventing any possible photochemical effects.

Materials.—The mercerized cotton samples used were prepared from ordinary absorbent cotton used in medical practice. As has been mentioned, variation in adsorption with the ash or iron content was to be investigated, and for that purpose, four different samples were made up. Three of these were prepared in the following manner: An amount of ferrous sulfate to give the desired concentration of iron was dissolved in two liters of water containing 20 cc. concentrated sulfuric acid. In this solution a 20 g. sample of cotton was steeped at 21–24° C. for about four hours, with occasional shaking, after which it was removed and centrifuged one or two minutes to remove excess ferrous sulfate solution. The material was then immersed in one liter of 17% sodium hydroxide solution, and allowed to stand at room temperature with frequent shaking for three to four hours. This treatment served both to precipitate the iron hydroxide on the fibres and to mercerize the cotton. On removal from the alkali, the sample was exposed to the air for a few minutes, then washed in distilled water until the test for hydroxyl ion with phenolphthalein was negative. Centrifuging was carried out for ten minutes to remove excess water from the sample, and subsequently it was pumped out over night in a vacuum desiccator.

The fourth sample was made up under conditions designed to give it an iron percentage as low as possible. Mercerization with ordinary sodium hydroxide would not accomplish this purpose, since iron is present as an impurity in solutions of the usual C.P. product, and is selectively adsorbed by cotton therefrom. But this very fact, according to Davidson,[3] furnishes a means of reducing greatly the amount of iron in such solutions, merely by immersing successively small portions of cotton in the concentrated alkali.

This means of purifying the sodium hydroxide was employed here. A saturated solution of alkali was treated with five successive small quantities of acid-washed cotton containing 0.0002% Fe; and this did indeed greatly lower the iron concentration of the solution. After filtration to remove cotton hairs, carbonate, etc., the NaOH content of the solution was determined and a portion of it diluted to the usual strength, 17%. As the cotton sample to be used for the mercerization was found to contain less than 0.001% Fe, it was subjected to no special treatment, such as acid washing. The mercerization was carried out in the usual manner with a 20 g. sample in one liter of the purified 17% solution, and yielded a product sufficiently low in iron.

The ash content of the samples was found by ashing in the standard way, and the percentage of iron in the ash was determined colorimetrically by the standard potassium thiocyanate method. The values found for the ash and iron in the four samples are given in Table I.

TABLE I

Ash and Iron Content of the Mercerized Cotton Samples

Number	% Ash	% Iron
I	0.042	0.0010
II	0.047	0.010
III	0.112	0.023
IV	0.16	0.09

Sample I was pure white; II, white; III, light yellowish; and IV, a brownish-red. The last significant figure varies not more than ± 2 units for the percentage ash and not more than ± 1 unit for the percentage iron.

The gases used were taken from tanks, dried by passage through a trap immersed in liquid air, and stored in glass bulbs.

Procedure.—In general the following rules were adopted for an experiment. In preparation for a run, the sample was always pumped out for 48 hours at 110° C., for it was found that only after such long pumping were reproducible results obtained. No residual pressure could then be read on the manometer, and no pressure developed on standing, even at the pumping-off temperature, indicating that no gas was being given off, either through desorption or decomposition. The desired bath was then substituted for the toluene bath, and two hours allowed for the sample to come to the temperature. A measured amount of oxygen was introduced in the adsorption vessel, the initial pressure noted, and, subsequently, pressure readings were taken over a period of four days. At the end of that time the experiment was discontinued, pumping was carried out at the temperature of the experiment for a short time, and was then continued for 110° for the requisite 48 hours.

As is usual, the amount of adsorption was calculated from a knowledge of the dead space as determined with helium.

Results

Adsorption experiments at liquid air temperatures.—Absorption experiments with oxygen were made on three of the mercerized cotton samples at liquid air temperatures. Allowance was made for the imperfect behavior of oxygen gas at these low temperatures. The correction to be applied was determined in two ways: by calculation, using van der Waals' equation, and by experiment. The latter was done by taking an empty bulb (of about the same volume as the dead space of the cotton-filled bulb) determining the amount of helium required to fill it at various pressures at a given liquid air temperature, then repeating with oxygen. The difference between the two gave the desired correction, and it turned out to be within 5% of that calculated from van der Waals' equation. The readings from an adsorption experiment with oxygen on a cotton sample were then corrected by the required amount, thereby yielding the data for the isotherms plotted in Fig. 1. As can be seen these are of the usual form, showing a gradual decrease from proportionality in the amount of gas adsorbed as the pressure is increased.

The adsorption at this temperature (— 192° C.) is characterized by the fact that the equilibrium is established immediately, indicating that the ordinary van der Waals physical adsorption prevails. Further, no noticeable difference exists between the adsorption capacities of the three samples with

different ash contents. Adsorption must therefore be taking place on the bulk of the cellulose, and the ash does not play any special role.

An isotherm obtained with nitrogen is shown, and it indicates that this gas is taken up in smaller amounts than is oxygen.

In a few measurements carried out at — 78°, no adsorption could be detected, even after several hours contact of gas and cotton.

Adsorption between 0 and 110° C.—The majority of the adsorption measurements with oxygen were carried out in the temperature range between 0 and 110° C. It is characteristic of the adsorption that it is not established immediately but takes place with a measurable velocity. In no instance was there any measurable difference between the initial amounts of

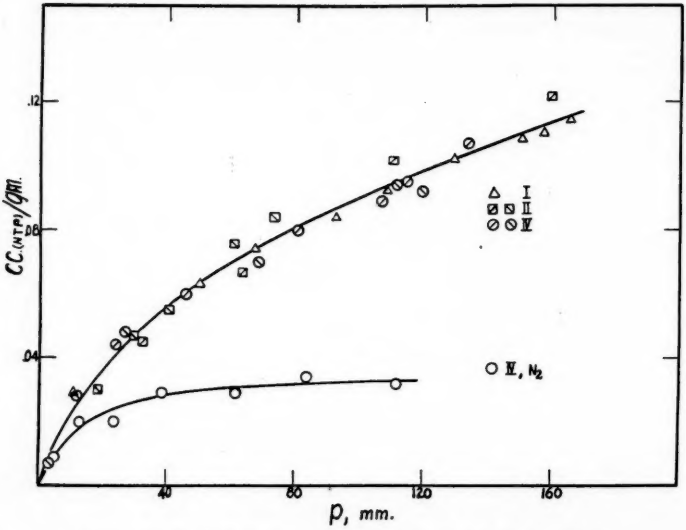

FIG. 1. Isotherms, 0_2 on Samples I, II and IV at — 192° C.

oxygen and of helium required to fill the adsorption vessel at the given temperature and pressure. With time, however, the pressure of oxygen decreased, whereas that of helium remained constant. These two points show that no measurable instantaneous adsorption of the type prevailing at liquid air temperatures occurred here, but that all the adsorption took place over a period of time. Actually, the velocity was so slow in most instances that experiments could not be extended long enough to reach an equilibrium. As a consequence, isotherms were not obtainable, and the data are best presented in the form of rate curves, in which the cc. (N.T.P.) of oxygen adsorbed per gram of sample are plotted against time in hours.

Fig. 2 reproduces results obtained for Sample II at 56° and 80° for various initial pressures of oxygen. Since equilibrium was not attained, the pressure effect can only be evaluated by considering the amounts of gas

taken up at the end of a given time interval. For example, on plotting the amounts adsorbed at 60 hours, against the pressure, the pseudo isotherm so formed is almost a straight line, bent but slightly towards the pressure axis. Results (not shown) of a similar nature were obtained for Sample IV at the same two temperatures, and it was assumed that the other two samples would show comparable behavior. The conclusion can be drawn that the gas taken up is almost directly proportional to the pressure, at temperatures below 80°, and pressures less than one atmosphere. In this range, therefore, the adsorption of oxygen by mercerized cellulose can be classed as weak.

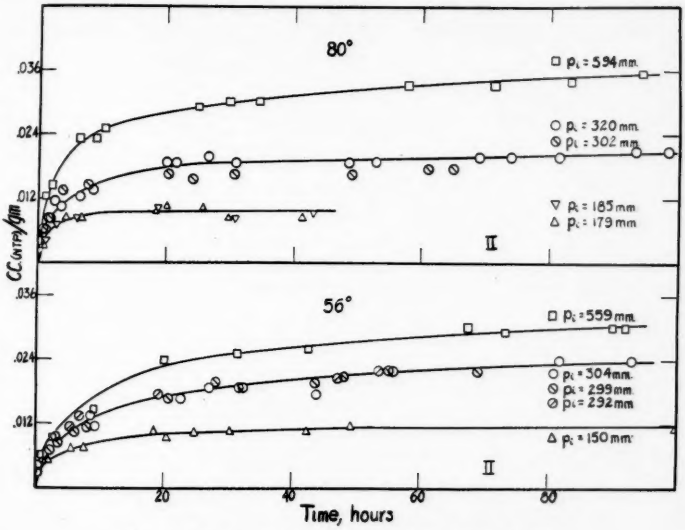

FIG. 2. Rate of Adsorption of O_2 by Sample II.

Figs. 3, 4, 5 and 6 show, for each of the four samples, the family of rate curves obtained at the temperatures 0, 35, 56, 80, 100 and 110° C., starting in each case with an initial pressure of about 600 mm. oxygen. The pressure can be considered as sensibly constant during the course of each run, because the maximum decrease in pressure under the experimental conditions amounts to less than 20 mm.; that is, about 3% of the total. This is well within the experimental deviation, estimated to be about 7%.

Discussion

Consideration of the complete set of rate curves makes it clear that in the process of taking up oxygen, all four samples show the same general behavior. This can be described broadly as follows: At zero ° C, the adsorption process is very slow, and after an initial period, there is little or no tendency for the velocity to decrease during the four days' time. The same is true at 36°, although the initial velocity is considerably greater

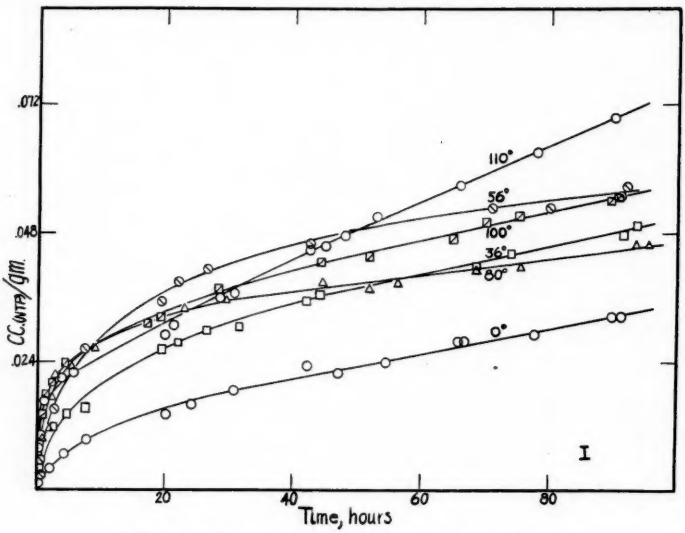

FIG. 3. Rate of Adsorption of 0_2 by Sample I.

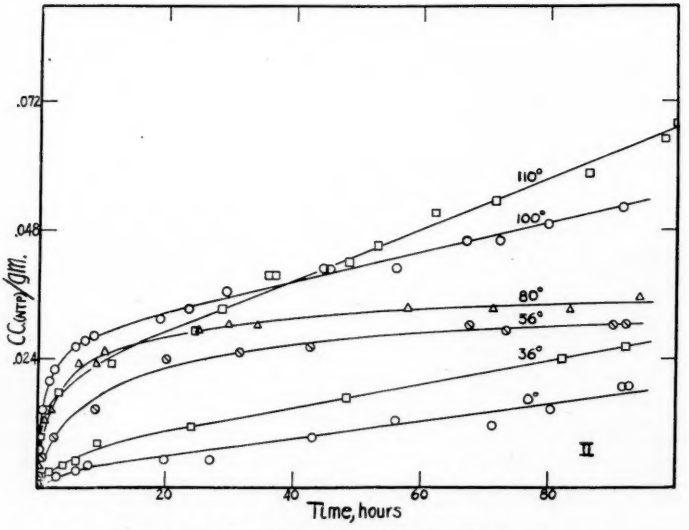

FIG. 4. Rate of Adsorption of 0_2 by Sample II.

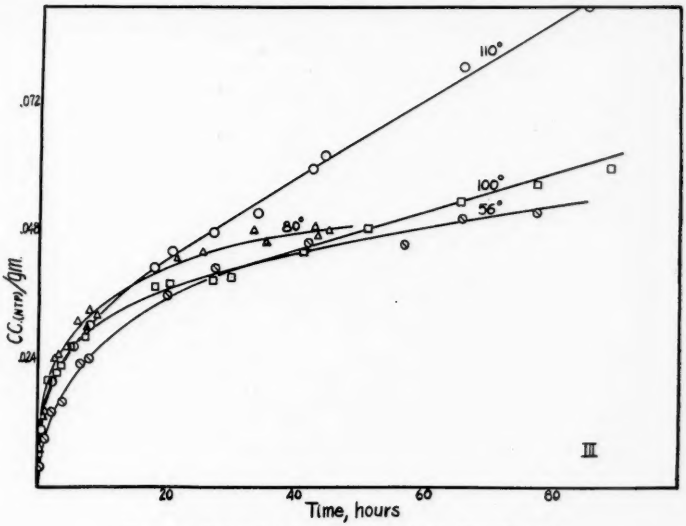

FIG. 5. Rate of Adsorption of 0_2 by Sample III.

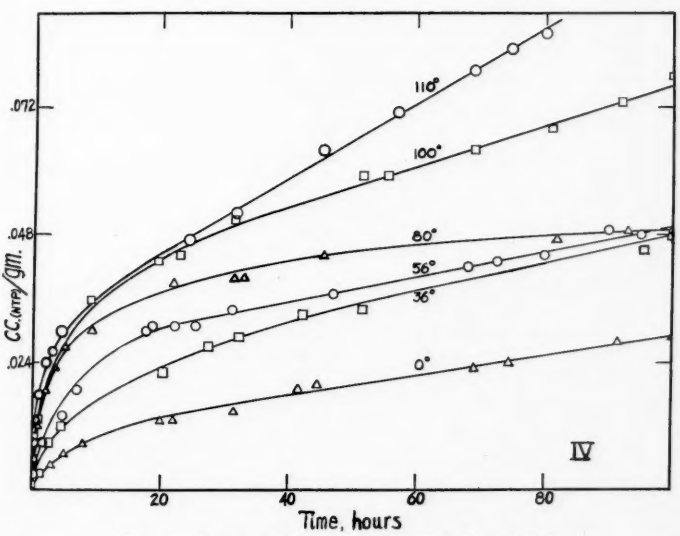

FIG. 6. Rate of Adsorption of 0_2 by Sample IV.

at this temperature. At 56° the rate curves start off much more steeply, then bend toward the time axis, and indicate therefore that the velocity of adsorption is tending to zero. At the still higher temperature, 80°, the initial rate is fast enough, and likewise the decrease in rate is rapid enough to bring the adsorption process to an end within the four days allotted; an equilibrium between the pressure and the amount of gas adsorbed has apparently been reached. At 100° the rate curves start out in the same manner as at the lower temperatures, but after a time, they become and remain straight lines. There is no evidence of curving towards the abscissa, showing that no equilibrium is ever attained. Similar remarks apply to the curves obtained at 110°.

Regarding the relative amounts of gas taken up, the curves indicate that, in time, the 56° curve will cross the 80° curve; for Samples I and IV it actually does so. Further, it can be predicted that the equilibrium amount finally taken up at 35° will surpass the amounts formed at 56 and 80°. Similarly, the amount adsorbed at 0° ought to be greatest of all, but it is difficult to say this positively, since the rate is so slow that only a small fraction of gas is adsorbed within four days. All the evidence indicates, therefore, that were it possible to carry the adsorptions to completion and construct isotherms, these would bear the usual relationship to one another, showing more gas adsorbed the lower the temperature.

The picture is different at temperatures above 80°. It is very evident that the total take-up of gas, as well as the velocity of the process, will always be greater at 110° than at 100°. Moreover, it is obvious that the amount adsorbed at 80° will never exceed that at 100°, for at the latter temperature the take-up is continuing at a constant rate at a time when, at the lower temperature, it has already reached an equilibrium.

To summarize: at 80° and below, the velocity of the oxygen take-up tends to decrease during an experiment until an equilibrium between the pressure and the amount adsorbed obtains; at 100° and above, the velocity becomes and remains constant and no equilibrium is approached. Again, in the range below 80° more gas is adsorbed at the lower temperature than the higher, while above 80° more gas is taken up at the higher than at the lower.

The results as described show very pointedly that, in the observed temperature interval, two processes play a role in the take-up of oxygen by mercerized cellulose. The dividing line between the two lies at about 80°, the one process occurring almost alone below that temperature, the other commencing there and becoming more predominant as the temperature is increased.

The foregoing facts also tell what kind of process is obtaining in each temperature interval. Below 80° the take-up has all the characteristics of a true adsorption proceeding with a measurable velocity. The amount of gas decreases with increasing temperature, whereas the velocity of adsorption increases with the temperature. These two facts are general for a slow adsorption process. Above 80° the take-up is an oxidation reaction, whose velocity is measured by the slope of the straight-line part of the curve. The rate and the amount of gas taken up both increase with increasing temperature.

It is believed, therefore, that below 80° a slow adsorption of oxygen, entirely similar to the adsorption of carbon dioxide, water vapor, nitrogen, etc., is taking place. This process is probably entirely reversible, all the gas very likely being recoverable as oxygen, with no carbon dioxide or

other oxidation products being produced. At about 80° the oxidation process is just beginning but is not yet important. By 100° it is proceeding at a rate very readily measurable, and at 110° quite rapidly indeed. This take-up of gas is undoubtedly not reversible, but oxidation products, probably carbon dioxide and water, must be formed. Since but small absolute amounts of these could be produced, and since both are much more strongly adsorbed than is oxygen, it is presumed that these product molecules will not appear in the gas phase, practically, and consequently they will not interfere with the pressure measurements.

From the picture as drawn above, the observed curves at 110 and 100° are not difficult to understand. Their form is indeed excellent evidence that adsorption must precede reaction in a heterogeneous one of this kind. The portion of the curves up to 15 to 20 hours are exactly like those at the lower temperatures, and show, therefore, adsorption at a rapid initial rate. Since the adsorption velocity decreases as more gas is adsorbed, and since, conversely, the oxidation rate increases as the amount of gas on the surface becomes greater, eventually a balance obtains, with the rate of oxidation equalling the rate of adsorption. The observed rate of gas take-up will thereafter be constant, a measure of the rate of oxidation.*

A quantitative differentiation of the adsorption and oxidation processes can be made by a comparison of the temperature coefficients of their respective velocities. This is shown in the following: The rates of the oxidation process at 100 and 110° can be readily determined from the slopes of the straight-line portion of the curves. These have been collected in Table II for all four of the samples.

TABLE II

The Velocity of Oxidation

Sample	Oxidation rate, cc/hr. $\times 10^4$ 100°	110°	$\frac{k_{110}}{k_{100}}$	E, cal.
I	2.66	5.18	1.94	19,000
II	2.86	4.75	1.66	14,500
III	3.78	7.19	1.90	18,000
IV	3.73	7.00	1.87	18,000

As can be seen, the absolute velocities vary from sample to sample, but (except for Sample II) the ten-degree temperature coefficients are quite constant. These latter may be expressed in terms of the apparent activation energy as calculated from the Arrhenius equation, $\log k = E/RT - B$, and provide values of E between 14,500 and 19,000 cals.†

* The oxidation rate will be dependent on the concentration of gas on the surface, but will not, of course, be controlled by the adsorption rate. This is true because what has here been called the "rate of adsorption" is actually the resultant of the rate of attaching and the rate of detaching the molecules from the surface. Below 80° desorption is the only process causing removal of oxygen from the surface, but above 80°, the additional factor, combination of oxygen with cellulose to form product molecules, also enters in. This latter happens at a slower speed than that at which the molecules are attached, so molecules are always supplied at a rate faster than they are used up by the oxidation; the speed of the oxidation consequently is independent of the adsorption speed.

† It is understood, of course, that the values quoted here for the activation energy of the oxidation process are not the true activation energies. If the adsorption of oxygen by cellulose in this range of temperatures and pressures is weak, as indicated by the results in Fig. 2 on the effect of pressure, the true activation energy is greater than the apparent activation energy by an amount equal to the heat of adsorption of oxygen on mercerized cellulose. (See Taylor, Treatise on Physical Chemistry, p. 1082, 2nd ed., D. Van Nostrand Co., 1931.) The order of magnitude of the activation energies will not be much changed by this.

The determination of the rate of adsorption at temperatures below 80° is complicated by the falling off in the speed as the process goes toward completion. The initial rates are naturally the fastest, since they measure the maximum speed of the gas take-up on the clean sample, and it is these rates which are to be compared with those of the oxidation process.

The adsorption rates for the first 10 to 20 hours can be simply represented by the entirely empirical equation $v = kt/1 - bt$, where v is the cc. of gas (N.T.P.) adsorbed at the time t, and k and b are constants. Using this equation to help smooth the curves, an average rate up to the time when 0.001 cc. of gas has been adsorbed may be determined. These values, for all four samples at all the temperatures, are given in Table III. The initial rates at 100 and 110° are included, because as explained above, the very first portions of the curves at these temperatures represent adsorption, and not oxidation.

TABLE III

Initial Rates of Adsorption

	Rate, cc/hr. × 10^3						
Sample	0°	35°	56°	80°	100°	110°	*E*, cal.
I	2.27	4.25	7.03	10.0	15.8	16.6	4,100
II	0.90	2.56	5.26	11.7	16.6	13.0	6,200
III	—	—	9.20	15.4	16.1	16.7	5,000
IV	2.10	3.90	6.70	11.1	11.1	19.3	4,600

When a log rate — 1/T plot is made of these data, lines which are essentially straight are obtained. The very pronounced deviation of the data is not surprising considering the difficulty of obtaining accurate initial velocities, especially at 100 and 110°. The best results are to be expected for the range 36 to 80°, and indeed at these three temperatures, the points lie reasonably well on straight lines. The values of the activation energy of adsorption range from 4000 to 6000 cals.* Great though the experimental deviation may be, it is clearly evident that the maximum E for the adsorption process is less than half the minimum E for the oxidation process. The two processes are thus sharply separated.

To demonstrate further that oxidation is occurring at the higher temperatures while none takes place at the lower, qualitative tests were made by means of a flow system. CO_2-free oxygen flowed at a slow rate over two separate portions of Sample IV, the one held at 80°, the other at 110° and the effluent gas from each system passed then through bubblers containing a saturated barium hydroxide solution. (The systems were flushed out first with nitrogen free from oxygen and carbon dioxide.) During the first 24 hours, a copious precipitate of carbonate was obtained from the sample at 110°, while but a trace resulted from that at 80°. Continuation of the experiment for four days showed that very small amounts of carbon dioxide were indeed produced at 80° and oxidation therefore sets in at a slow rate at this temperature.

From the oxidation rate measured in the static system at 100 and 110° (Table II) a rough oxidation rate of Sample IV at 80° can be calculated. The figure obtained is 0.95×10^{-4} cc/hr. This rate is about within the

* The term "activation energy of adsorption" is used here merely as a convenient means of representing the temperature coefficient of the velocity of adsorption, to aid comparison with the temperature coefficient of the oxidation reaction. Its use is not intended to imply that the adsorption process dealt with here is similar to "activated adsorption," as the nature of the adsorption process in the present instance and the reasons for the observed velocity are unknown.

experimental error, but actually the observed speed of take-up of gas on Sample IV between the third and fourth day was just about 0.70×10^{-4} cc/hr. Thus the calculated oxidation speed at 80° is checked both by the observation in the static adsorption experiments and by the qualitative flow experiments.

The case is otherwise at 56°. The oxidation rate for Sample IV at that temperature, as calculated from the rates at 100 and 110,° would be 0.014×10^{-4} cc/hr. This is far too small to be measured in the present apparatus. Yet the observation at this temperature is that a more or less straight line, representing an oxygen take-up of 2.14×10^{-4} cc/hr., is found over a considerable period of time. It is clear, therefore, that the process yielding this apparent straight line cannot be the same as that giving the constant rate at 100°.

The conclusion is inescapable that at temperatures above 80° the adsorption of oxygen on the surface of mercerized cellulose is followed by a different process involving oxidation of the surface cellulose molecules by the adsorbed oxygen. Below 80° the whole process is one of adsorption.* Two kinds of adsorption exist, however; the one is measurable at liquid air temperatures, and takes place very swiftly, perhaps instantaneously; the other is distinguishable at 0° and takes place very slowly. Whether these are the same types of adsorption, involving merely the outside surface in the former instance, and the surface of the pore walls as well in the latter case, does not seem to be readily determinable.

The investigation has failed to establish a correlation between the iron content of the mercerized cellulose and the amount of oxygen taken up. Thus, with successive increases in iron of ten-fold, two-fold and four-fold on passing down the series from Sample I to IV, the rate first decreases, then increases, and finally decreases again. This implies that, although the runs on a given sample make a consistent whole, comparison of results from sample to sample is not possible. Evidently very close control of all conditions during the preparation of the samples is necessary in order that samples may be strictly comparable. Also, it is questionable whether such a material as Sample I, which underwent no impregnation with iron solution, should ever be compared with others of a series where iron had been added; probably the iron inherent in the ash is present in a form different from that added artificially.

In spite of these remarks, however, there seems to be a definite relationship between the total ash content and the rate of oxidation. As Table I shows, the four samples fall roughly into two groups, Samples I and II having an equal ash content of 0.045%, while Samples III and IV have three to four times as much, 0.11% and 0.16%, respectively. Corresponding to these low and high ash groups, the rates of oxidation are slow and fast, according to Table II. For example, at 100° C. Samples I and II have about the same oxidation rate, 2.66 and 2.86×10^{-4} cc/hr.; the oxidation of Samples III and IV at the same temperature proceeds some 35% faster, both showing a rate of 3.7×10^{-4} cc/hr. The same relationship holds at 110° C. It seems evident that here the increased ash content is accompanied

* It is noteworthy that an exactly analogous situation has been found in the take-up of oxygen by coal. Tideswell and Wheeler (J. Chem. Soc., *115*, 895 (1919); *117*, 794 (1920)) have observed rate curves similar in character to those depicted here, although the temperature at which oxidation begins to be noticeable is some 50° below that for mercerized cellulose. The interpretation provided by Francis and Wheeler (J. Chem. Soc., *1927*, 2964) is that "the oxidation of coal takes place through the medium of an adsorbed layer. . . ."

by increase in the rate of oxidation. This is, of course, in line with most observations on the effect of ash on rate of deterioration of cellulose materials.

Concerning the cause of the increased oxidation rate with increased ash content, but little definite evidence is at hand. The fact that for all four samples, the temperature coefficient of the oxidation is about the same argues that the higher concentration of ash does not increase the rate of oxidation by changing the actual oxidation process. Further, the fact that the activation energy for the velocity of the adsorption process between 0° and 80° averages about 5000 cal. for all four samples would suggest that the speed of the adsorption process is not altered by change in amount of ash. Consequently, the increase in oxidation rate would seem to be effected by increase in amount of gas adsorbed. Some evidence of this is actually to be found from the curves of Figs. 3 to 6. It is noticeable there that for the two samples high in ash, the straight line portions of the curves at 100 and 110° begin when larger amounts of oxygen have been adsorbed than is the case with the low ash samples; the amounts are estimated at about 0.036 and 0.024 cc/gm., respectively. Whether this change in amount adsorbed is due to change in adsorbing surface area or to change in the heat of adsorption as the ash content increases is not indicated by these experiments. To obtain this information, isotherms at various temperatures on comparable samples would be required. As pointed out previously, the extreme slowness with which equilibrium is established prevents obtaining the desired data, and consequently a decision on this important point cannot yet be reached.

The author wishes to express his thanks and sincere appreciation to Prof. Hugh S. Taylor for his interest and very real help in the carrying out of this work.

Grateful acknowledgment is made to The Textile Foundation for the Fellowship which made this research possible.

Summary

1. The take-up of oxygen by mercerized cellulose samples of various ash contents has been investigated at — 192° C., and in the temperature range from 0° C. to 110° C.

2. At — 192° C. a rapid physical van der Waals' adsorption of oxygen by mercerized cellulose occurs; the adsorption is not affected by the ash content of the sample.

3. Between 0° C. and 80° C. oxygen is adsorbed by mercerized cellulose at a measurable rate and a true equilibrium can be attained at each temperature. The temperature coefficient of the velocity of the adsorption corresponds to an activation energy of about 5000 cal.

4. Above 80° C. an oxidation of the mercerized cellulose by the adsorbed oxygen sets in. The apparent activation energy of the oxidation reaction is about 18,000 cal. The oxidation process is sharply differentiated from the adsorption process.

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Comparison of Three Methods for Determining the Breaking Strength of Cotton Fibres

By MARY ANNA GRIMES *

Summary

A method is presented for determining the breaking strength of cotton fibres. Combed fibres are cut to a definite length, weighed, taped with drafting tape, and broken in the usual fabric breaking machine. The equipment and time required for preparation, breaking and calculations are less than required for the Chandler bundle method and the results have been found to be as satisfactory.

Introduction

STRENGTH is one of the most difficult to determine of all the physical properties of cotton fibres. For many years two methods have been used. In one the strength of an individual fibre is determined and an average of a large number, probably 500 or more, of these individual determinations is assumed to be the breaking strength. The second method as now used is a modification of the Chandler bundle method.[1, 3] A bundle of combed fibres is wrapped with thread, then broken in special jaws and the breaking strength per cross-sectional area determined on the basis of the circumference, making certain corrections for the thread, variations in size, etc. The average of ten or more such breaks is considered the true strength. The first method requires only one piece of equipment—a single fibre breaking device. The second requires a special bundle wrapping device and specially constructed jaws for use in a breaking strength machine. Both are time consuming, particularly the single fibre method, and for this reason their use is limited. The bundle method requires considerable practice in wrapping and breaking for satisfactory results, and even experienced operators may have as high as 25% of the bundles or breaks to discard because of slippage or breakage in the wrapping device or slippage in the jaws of the breaking machine.[3] The leather lining of the jaws used in breaking must be renewed frequently.

Another method has recently been reported by Guy F. Crowley, which he calls the flat bundle test.[2] He has found this method satisfactory for fibres such as silk and rayon which can be cut to definite lengths of approximately three in. The parallel fibres are pasted between strips of

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adhesive tape with the edges touching, and the break made between ordinary fabric jaws set to touch. The breaking strength per cross-sectional area is then calculated.

Experimental

It was suggested by Prof. E. R. Schwarz and others at Massachusetts Institute of Technology that cotton fibres could be broken in the same manner using the cotton classer's estimate of the length, and using drafting tape, which is easier to manipulate and less expensive than the adhesive tape. The area of the cross-section is calculated by the formula,

$$\text{area} = \frac{\text{weight}}{\text{density} \times \text{length}}$$

and the strength per cross-section by the formula,

$$\text{strength} = \frac{\text{machine break}}{\text{area}}$$

In an endeavor to find a method more rapid than the Chandler bundle, this suggested method and modifications have been tried at this station, using cottons ranging in length from 13/16 to 1¼ in.

Seventeen samples of different cottons, each containing at least 10 specimens, were broken by this method using the cotton classer's estimate of length, but it was found there was greater variation within each lot and between lots than by Chandler method, as shown in the accompanying table. It is believed this variation was due to differences in the propor-

RESULTS OBTAINED BY THREE METHODS FOR DETERMINING THE STRENGTH OF COTTON FIBRES

Chandler Bundle				Cut to ⅝ inch weighed, and taped		Uncut, weighed, and taped		Scores		
Number of cotton	Number[1] of breaks	Strength in thousand lbs. per sq. in and standard error	S. E. as % of mean	Strength in lbs. per gram of cotton and standard error	S. E. as % of mean	Strength in lbs. per unit area and standard error	S. E. as % of mean	Chandler bundle	Cut, weighed, and taped	Uncut, weighed, and taped
1	100	59.6 ± 1.08	1.81	2030 ± 12	0.59					
2	100	71.2 ± 0.48	0.67	3200 ± 27	0.84	2350 ± 36	1.53	6	6	4
3	100	57.1 ± 0.47	0.82	1900 ± 15	0.79					
4	25	70.4 ± 1.18	1.68	2690 ± 34	1.26					
5	25	72.7 ± 0.83	1.14	3030 ± 27	0.89					
6	25	74.7 ± 0.89	1.19	3100 ± 47	1.52					
7	25	72.7 ± 0.84	1.16	2740 ± 45	1.64					
8	10	56.6 ± 1.25	2.21	1990 ± 36	1.81	1940 ± 38	1.96	3	4	4
9	10	52.9 ± 0.99	1.87	1990 ± 38	1.91	1770 ± 43	2.43	4	4	3
10	10	49.0 ± 1.06	2.16	1940 ± 41	2.11	1740 ± 13	0.75	3	3	6
11	10	50.0 ± 1.06	2.12	2000 ± 38	1.90	1630 ± 24	1.47	3	4	5
12	10	54.1 ± 0.68	1.26	2010 ± 25	1.24	1540 ± 29	1.88	5	5	4
13	10	67.7 ± 0.64	0.95	2360 ± 47	1.99	2190 ± 51	2.33	6	4	3
14	10	66.3 ± 0.65	0.98	2220 ± 27	1.22	2180 ± 30	1.38	6	5	5
15	10	67.3 ± 0.76	1.13	2060 ± 40	1.94	2180 ± 47	2.16	5	4	3
16	10	67.0 ± 1.01	1.51	1970 ± 41	2.08	1830 ± 46	2.51	4	3	2
17	10	63.5 ± 1.07	1.69	1950 ± 25	1.28	1860 ± 39	2.10	4	5	3
18	10	63.9 ± 0.82	1.28	1810 ± 27	1.49	1640 ± 29	1.77	5	5	4
19	10	62.5 ± 0.84	1.34	1870 ± 40	2.14	1610 ± 24	1.49	5	3	5
20	10	58.8 ± 1.06	1.80	2050 ± 29	1.41	2110 ± 45	2.13	4	5	3
21	10	59.5 ± 0.99	1.66	2175 ± 34	1.56	1800 ± 59	3.28	4	4	1
22	10	57.1 ± 0.96	1.68	2050 ± 33	1.61	1670 ± 43	2.57	4	4	2
23	10	56.3 ± 1.67	2.97	1990 ± 35	1.76	1750 ± 53	3.03	2	4	1
								Total 73	72	58

[1]Total number of breaks — Chandler and cut 460 each and uncut 260.

tion of fibres of the various lengths within each bundle of fibres and to errors in estimating the length of the fibres. Upon making fibre arrays it was found that the lengths as estimated by a cotton classer were not sufficiently accurate for the purpose. It is believed this method would be quite satisfactory when used in conjunction with fibre arrays.

It was decided to try cutting the bundle of fibres to a length of ½ in. A cutting gage was made by joining with a hinge of adhesive tape, strips of transparent celluloid 0.016 in. thick, ½ in. wide, and approximately 3½ in. long. The bundle of fibres, which had been carefully combed as for the Chandler bundle, but left flat, was placed as uniformly distributed as possible, on one side of the gage so as to extend between marks ¾ in. apart as shown in Fig. 1.

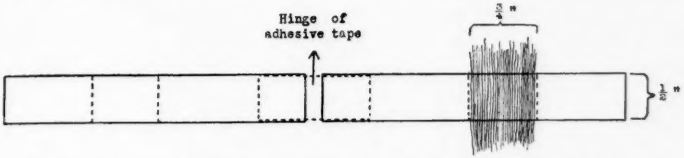

FIG. 1. Diagram showing arrangement of fibres before closing gage, cutting fibres, weighing and taping.

The other half of the gage was turned over the cotton. With the gage held firmly between the fingers, the ends of the fibres extending beyond the gage were cut off with sharp dissecting scissors. The gage and cotton were weighed, the weight of the cotton being kept between 0.025 ± .005 grams. The gage was opened and two strips of 1-inch drafting tape placed across the cotton and lengthwise of the gage, the tape meeting in the center of the cotton and gage. The tape was lifted from the gage with the cotton adhering to it, turned and the tape folded to cover the other side of the bundle (Fig. 2). The prepared bundle was placed between 2-inch fabric jaws,

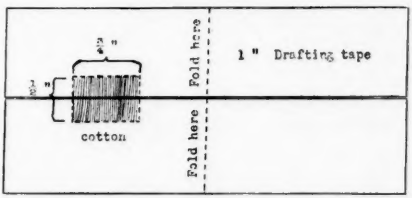

FIG. 2. Diagram showing taping of cotton fibres after cutting and weighing.

the edge of the jaws touching and the outside edge of the tape and jaws coinciding, and the bundle broken. No slippage occurs within the jaws in this method, and the bundle breaks quickly and sharply although there is greater elongation than in the Chandler bundle. The strength of the cotton may then be determined by either of two methods: The strength per cross-

sectional area may be determined by the formula already given; or the strength in pounds per gram of cotton of this length found by dividing the machine break by the weight of the cotton. The latter method is of course simpler and is satisfactory for comparisons of cottons broken by the same method, but neither can be converted into terms comparable to the results obtained by the Chandler method.

Results Compared

Unfortunately, the true strength of the various cottons used is not known so there is no standard by which these methods may be judged. However, the strengths of the same cottons broken by each of the three methods and the standard errors as percentages of the means were determined. The standard errors as percentages of the means were scored by a scale containing six intervals of 0.50 each, beginning with 0.50%, and with the highest score given to the lowest error as percentage of the mean. The results of these tests are given in the accompanying table. The score for the Chandler method is shown to be 73, the cut-weighed-taped 72, and the uncut-weighed-taped 58. These figures indicate that the first two methods are of approximately equal accuracy.

In the analysis of the strength of 23 other lots of cotton, not included in the tabulated data, each with two variables due to treatment, 230 breaks were made by each of the three methods. The variations due to treatments and methods of breaking were determined by Snedecor's[4] method. The variations due to methods were found to be 5.83 for the Chandler bundle, 5.82 for the cut-weighed-taped, and 7.98 for the uncut-weighed-taped method. This analysis indicates that in this case the Chandler bundle and the cut-weighed-taped methods were equally satisfactory and verifies the conclusions drawn from the data for the first 23 samples.

It is believed that the uncut-weighed-taped method, is suitable for routine work where great accuracy is not demanded, and when used in conjunction with fibre arrays may prove to be sufficiently accurate for research purposes. The cut-weighed-taped method has been found to be as accurate as the Chandler bundle method. The chief advantages of the proposed taped methods over that of the Chandler bundle method are the saving of considerable time and energy and the elimination of the wrapping device and the special jaws.

References

1. "A. S. T. M. Standards on Textile Materials," Committee D–13, pages 167–172 (1935).

2. Crowley, Guy F. 1935. "A method of testing fibres for the determination of tensile strength in terms of unit area, to be known as the flat bundle test." "A. S. T. M. Standards on Textile Materials," D–13, page 234. Also personal communications from the author.

3. Division of Cotton Marketing, Bureau of Agricultural Economics, U. S. D. A. Correspondence and visits with members of staff.

4. Snedecor, George W. 1934. "Calculation and interpretation of analysis of variance and covariance." College Press Inc., Ames, Iowa.

Abstracts

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I. Fibres (Synthetic and Natural) and Fibre Analysis

Adsorption of Water by Wool. Part I. Adsorption Hysteresis. J. B. Speakman and C. A. Cooper. *J. T. I.*, July 1936, P. T183–96.

In view of the alternations in adsorption and desorption experienced by wool in everyday processing, it is important to know the range of humidity over which wool must be dried in order to pass from adsorption to desorption conditions when the regain is below saturation. This is particularly true of worsted processes, where the backwashed sliver first loses water up to and including combing, regains water during storage of the top, and then loses water steadily during drawing and spinning. Since the behavior of the wool in spinning depends to a large extent on the rigidity of the fibres, which is very sensitive to the amount of adsorbed water, the conditions of top storage in relation to the humidity of the spinning room should be such that the wool undergoes drawing and spinning under desorption conditions. It is not known, however, what difference in humidity should obtain in order to ensure this result, and experiments were carried out in order to remedy the deficiency.

It was shown that the short-range desorption experiments define the course of drying from adsorption to desorption conditions for wools at different initial regains. The range of humidity over which wool must be dried in order to pass from adsorption to limiting desorption conditions

seems to be independent of regain and is about 18%. In order, therefore, to ensure optimum spinning conditions, and make the least demand for artificial humidification of the spinning room, the humidity of the atmosphere in which tops are stored prior to drawing and spinning should be at least 18% higher than that of the spinning room.

PART II. INFLUENCE OF DRYING CONDITIONS ON THE AFFINITY OF WOOL FOR WATER. J. B. Speakman and Miss E. Stott. *Ibid.*, P. T186–90.

When wool is dried from regains below saturation, its adsorptive power decreases with increasing temperature of drying. The reduction is produced by partial as well as complete drying, but not by drying from saturation, nor by heating wool dried at a low temperature. A normal affinity for water may be restored to wool, which has been dried at a high temperature, by allowing it to reach saturation with water vapor. On the other hand, the reduced adsorptive power of wool heated over water at a high temperature is irreversible.

PART III. INFLUENCE OF TEMPERATURE ON THE AFFINITY OF WOOL FOR WATER. T. B. Speakman and C. A. Cooper. *Ibid.*, P. T191–96.

The adsorption isotherms of English Leicester wool have been determined at intervals of 5° C, from 25° C to 55° C. Above 55° C complete isotherms could not be obtained because the disulphide bond of wool is attacked and hydrolyzed by water vapor at high temperatures. The products of hydrolysis react with mercury vapor from the manometer to form mercuric sulphide on the wool, but in absence of mercury vapor volatile, sulphur-containing compounds are evolved. At low partial pressures of water vapor, the isobars for wool indicate that the amount of water adsorbed decreases as a linear function of temperature. When the partial pressure is 0.975, however, the isobar shows a minimum at about 43° C, confirming the view that the swelling of wool in water is a minimum in the neighborhood of 40° C. (C)

AMERICAN COTTON CROP: RECENT DEVELOPMENTS IN THE METHODS USED TO PRODUCE THE. A. F. W. Coulson. *J. T. I.*, July 1936, P. 249–74. (C)

CARBONIZATION OF WOOL BY ALUMINUM CHLORIDE. L. Armand. *Tiba*, 1935, V. 13, P. 753–9; *C. A.*, 1936, V. 30, Col. 5799. (W)

CELLULOSE: TRUE DENSITY OF. W. B. Campbell and J. K. Russell. *Quart. Rev. Forest Prod. Lab. Can.*, 1935, V. 21, P. 24–6.

The d. of cotton cellulose does not vary according to the nature of the liquid medium if precautions are taken to avoid intermediate drying. It is believed that the results lend support to the conception of shrinking by forces of internal liquid tension, bonding by recrystallization, and the formation of pockets in the structure, when cellulose is freed from H_2O. (From *C. A.*, 1936, V. 30, Col. 5407.) (W)

CROSS-SECTIONAL VARIABILITY OF WOOL FIBRES. J. I. Hardy. *Rec. Procs. Am. Soc. Animal Production, 28th Annual Meeting*, 1935, P. 144–46.

A discussion on the variability of cross-sections of wool fibres obtained by using the author's fibre-holding device (*Tex. Rsch.*, 1935, V. 5,

P. 184–90; *J. T. I.*, 1935, P. A316). Cross-sections of samples are being prepared to show low, medium and high standard deviations in fibre distribution for each commercial grade. These samples are to be used as a basis for the selection of breeding animals. (From *J. T. I.*, July 1936, P. A336.) (C)

FLAX PRODUCTION IN GREAT BRITAIN: PAST AND FUTURE OF. G. O. Searle. *J. T. I.*, July 1936, P. P197–207. (C)

JUTE: COMPOSITION OF SOME VEGETABLE FIBRES WITH PARTICULAR REFERENCE TO. Arthur G. Norman. *Biochem. J.*, 1936, V. 30, P. 831–8.

Vegetable fibres of many types fall into two groups depending on the xylan content of the fibre cellulose. The group low in xylan includes flax, ramie and Italian hemp, while the group high in xylan includes coarser fibre such as jute, manila hemp and sisal which also contain appreciable amts. of lignin and encrusting hemicelluloses. No direct relationship was found between quality and xylan content of a large no. of jute samples. The resistance or susceptibility of isolated cellulose to such treatments as boiling with dil. alkalies cannot be deduced from the xylan content owing to the presence of varied amts. of easily extd. hexosan. (From *C. A.*, 1936, V. 30, Col. 5418.) (W)

MOLECULAR STRUCTURE OF CELLULOSE. G. F. Davidson. *J. T. I.*, July 1936, P. P144–68; *Tex. Mfr.*, June 1936, P. 233.

Part I contains a review of current theories, with list of references. In Part II is presented the evidence of the chemically modified cotton celluloses. It is largely a review of research conducted at Shirley Institute, reports of which were published in *J. T. I.* from 1923 to 1934 inclusive. (C)

NON-SHRINKING WOOL. A. Foulon. *Deut. Wollen-Gewerbe*, 1936, V. 68, P. 739–40.

Wool is probably rendered non-shrinking by treatment with acid hypochlorite soln. because the Cl attacks and nearly completely destroys the small scales which form the exterior layer of the woolen hair and give it its particular appearance. Arguments for and against this view are given. Wool can also be rendered non-shrinking by the action of Al or Cr sulfate. The influence is only temporary, however, in the case of the sulfates and it is removed by washing or treatment with an acid. Non-shrinking wool can also be obtained by treatment with gaseous Cl or Br. (From *C. A.*, 1936, V. 30, Col. 5420.) (W)

PROTEIN RAYONS: PRODUCTION. K. Grafe. *Angew. Chem.*, 1936, V. 49, P. 303–7.

A general account is given of the action of alkalis, acids, neutral salts, organic dispersion agents, chlorinating and oxidizing substances, reducing substances and bacteria on proteins. It is shown that it is not possible by means known at present to dissolve wool keratin (so as to give a spinnable solution) without serious structural change. (From *J. T. I.*, July 1936, P. A311.) (C)

SEED AND LINE FLAX FOR "COTTONIZATION." G. A. L. *Tex. Mfr.*, Aug. 1936, P. 295, 310.

Some facts which are obstacles to utilization of seed flax straw. A comparison between seed flax and fibre flax for the purpose of "cottonization." (C)

SEPARATION OF WOOL INTO ITS HISTOLOGICAL COMPONENTS. R. Haller and F. W. Holl. *Kolloid Z.*, 1936, V. 75, P. 212–17.

The wool is sepd. into its histological components, cortical cells, scale cells and cementing material, by means of concd. ammonia. A S-free protein, named "Lanain," was obtained from the cementing material. The denatured "Lanain" redissolves in concd. ammonia and it can be pptd. again from this soln. This, therefore, gives a method for the regeneration of denatured proteins. An unknown cryst. substance, insol. in water, alc. and ether, m. 110°, was isolated from the wool. The use of concd. ammonia for the decompn. of dyed wool was not successful. (From *C. A.*, 1936, V. 30, Col. 5419.) (W)

SORPTIVE PROPERTIES OF THE SILK FIBRE. R. Cuthill. *Tex. Mfr.*, June 1936, P. 208; *J. T. I.*, July 1936, P. P275–81; *Tex. Rec.*, 1936, V. 54, P. 33; *Silk J.*, 1936, V. 13, No. 145, P. 27; *C. A.*, 1936, V. 30, Col. 5799.

A survey and bibliography of published information on this topic. No attempt is made to deal with the question of silk weighting, the patent literature of which is remarkably extensive. (C)

II. YARNS AND FABRICS

RAYONS AND LINSEED-OIL SIZES. W. Weltzien. *Monatsh. Seide Kunstseide*, 1936, V. 41, P. 32–7.

Linseed-oil sizes are used particularly for high-grade textiles. Advantages of strand sizing with this oil are enumerated, and a review is given of several characteristic properties and relationships dealing with the high smoothness of a good linseed-oil size, the stability of the sizing, the stability test (dry heat at 105° for three hrs.), the tropical test (heating for four hrs. to 80°, at a relative air humidity of 90%, in an oil bath), ease of desizing, damages to the fibres and strength measurements. (From *C. A.*, 1936, V. 30, Col. 2011.) (W)

REELING QUALITY OF DYED RAYON. W. Kegel. *Monatschr. Textil-Ind.*, 1936, V. 51, P. 19–20.

A discussion of the reasons why dyed rayon usually can be wound on reels only poorly or not at all and methods of overcoming this difficulty. (From *C. A.*, 1936, V. 30, Col. 2391.) (W)

RUBBER LATEX: APPLICATION TO TEXTILES. H. P. and W. H. Stevens. *Trans. Inst. Rubber Ind.*, 1935, V. II, P. 67–88; *J. T. I.*, April 1936, P. A171.

Patent processes for the impregnation of textiles with rubber latex are reviewed and observations on the penetration of fibrous materials by latex are critically discussed. (C)

SEPARATION OF FLAX FIBRES FROM THE PLANT STEM. Dr. W. H. Gibson. *Tex. Mfr.*, June 1936, P. 226; *J. T. I.*, July 1936, P. P298–306.

Chemical retting, "green" flax breaking and scutching, and "cottonization" of flax. Abstract of a paper read at Textile Institute Conference, London, June, 1936. (C)

SHEARING CAPACITY OF SYNTHETIC YARNS. Anon. *Am. W. & C. Rptr.*, June 18, 1936, P. 11–12, 20.

Compared with hard twisting values: Three sets of yarns are tested. Percentages of elongation, relation between tensile strength and shearing points are tabulated and discussed. (C)

SHRINKING PROPERTIES OF CRÊPE YARNS FROM STAPLE FIBRE. W. Weltzien and J. Buchkremer. *Seide u. Kunstseide*, 1936, V. 41, P. 109–13.

Investigation of the shrinkage and other properties of staple fibre crêpe yarns by means of a swelling apparatus described, have indicated that the twist has the greatest influence on the more important properties. In this respect staple fibre crêpe yarns differ from rayon crêpes, because the properties of the latter are more dependent upon the nature of the size used. The swelling apparatus described can be used to determine with reasonable accuracy the crêping qualities of various yarns, as well as to control their manufacture. (Copied from *J. Soc. Dyers Col.*, May 1936, P. 191.) (C)

SIZING AND FINISHING OF STAPLE FIBRE FABRICS. *Tex. Wkly.*, 1936, P. 192.

For the sizing of staple fibre fabrics the article does not recommend sago starch as it is difficult to remove in the scouring bath. A satisfactory size is wheat starch mixed with a small amount of white softening. When tallow is used, a saponifying agent has to be added, otherwise the size floats as an oily film on the surface of the scouring bath, forming spots on the cloth and causing uneven dyeing. Desizing is effected by a caustic soda treatment that also facilitates crêping. Fabrics consisting of staple fibre and cotton require bleaching, chlorine and hydrogen peroxide, or peroxide alone being suitable. The article refers briefly to the process of porous impregnation with a water-repellant substance. (From *Rayon & Mell.*, June 1936, P. 94.) (C)

STAPLE FIBRE FABRICS: SIZING AND FINISHING. *Tex. Wkly.*, 1936, V. 17, P. 141, 192; *J. T. I.*, April 1936, P. A161. (C)

STAPLE FIBRE SPINNING. S. Miura. *J. Soc. Tex. Inst., Japan*, 1935, P. 91.

The writer sketches the various arrangements of the fibre at every stage of staple fibre spinning on a cotton spinning frame, and by means of a magnifying glass studies parallelization and uniformity. He comes to the conclusion that a good yarn cannot be produced by parallelization only, and that more stress must be laid upon uniformity. The working process must be shortened as much as possible, in order to reduce fatigue of the fibre or to avoid breakage. (From *Rayon & Mell.*, June 1936, P. 94.) (C)

STAPLE RAYON AND ITS IMPORTANCE IN THE CLOTHING INDUSTRY. Völkel. *Spinner u. Weber*, 1936, V. 54, No. 12, P. 1–3.

A survey of uses and review of phys. and chem. properties. (From *C. A.*, 1936, V. 30, Col. 3652.) (W)

SYNTHETIC YARN DIFFERENCES. Anon. *Am. W. & C. Rptr.*, July 16, 1936, P. 7–8, 39–40.

Yarns of same type, denier and filaments may differ in tensile strength, elongation and shearing characteristics, and affect fabric results. (C)

SYNTHETIC YARN ELONGATION. Anon. *Am. W. & C. Rptr.*, June 4, 1936, P. 5–6, 15.

Its importance in hard twisting; different yarns compared; what tests show in tensile strength and percentage elongation; shearing points in turns. (C)

TEXTILE DRYING. *Tex. Wld.*, June 1936, P. 98–9.

Need for research on problem of textile drying shown at conference of U. S. Institute for Textile Research, held in New York City May 6, 1936. (C)

TEXTILE DRYING APPARATUS James T. Hunter. *Tex. Bull.*, July 16, 1936, P. 8, 12, 26; *Tex. Rsch.*, June 1936, P. 369–73.

Paper presented at conference on textile drying sponsored by U. S. Institute for Textile Research held in New York City May 6, 1936. (C)

WARP TENSION DURING WEAVING: NEW METHOD OF RECORDING THE. H. Uchida. *J. Soc. Tex. Inst., Japan*, 1935, P. 145; *Rayon & Mell.*, June 1936, P. 95.

A warp tension recorder has been devised for measuring the tension between the back-rest and the lease-rod. (C)

WARPING AND SIZING. Warren F. Cooper and Carl C. Mattmann, Jr. *Tex. Wld.*, July 1936, P. 78; *Am. W. & C. Rptr.*, Sept. 3, 1936, P. 16, 31.

Speeds, tensions, and temperatures recommended for acetate yarns. (C)

WORSTED TWISTS: SURPRISING IRREGULARITIES SHOWN BY TESTS. George Hendricks. *Tex. Wld.*, June 1936, P. 93. (C)

III. CHEMICAL AND OTHER PROCESSING (NOT OTHERWISE CLASSIFIED)

ACID AND ALKALINE DEGRADATION OF CHLORINATED WOOL. Florence Barr, Mildred Barr and Rachel Edgar. *Iowa State Coll. J. Sci.*, 1936, V. 10, P. 145–50; *C. A.*, 1936, V. 30, Col. 4677. (W)

ACID DEGRADATION OF WOOL KERATIN. Mildred Barr and Rachel Edgar. *Iowa State Coll. J. Sci.*, 1936, V. 10, P. 129–34; cf. *C. A.*, V. 29, Col. 3521; 1936, V. 30, Col. 4676. (W)

ACID WOOL DYES: CHARACTERISTICS OF—AND THEIR BEHAVIOR DURING DYEING. Hugo vom Hove. *Z. ges. Textil-Ind.*, 1936, V. 39, P. 232–3; *C. A.*, 1936, V. 30, Col. 4325. (W)

ANILINE BLACK DYEINGS. Ed. Justin-Mueller. *Tex. Mfr.*, 1936, V. 62, P. 74.

The action of aromatic O carriers is discussed and chem. equations are given for the formation of aniline black in the presence of aromatic oxida-

tion assistants or O carriers to demonstrate how a better utilization of aniline oil may be obtained. (From *C. A.*, 1936, V. 30, Col. 3241.) (W)

AZO DYES. Paul Ruggli. *IX Congr. intern. quim. pura aplicada*, 1934, V. 4, P. 414–20; cf. *C. A.*, 1935, V. 29, Col. 2359; 1936, V. 30, Col. 3240.

Various aspects of investigations of azo dyes are discussed. (W)

BENZO FAST COPPER DYES: APPLICATION OF. K. Ottenschläger. *Mell. Textilber.*, 1935, V. 16, P. 283–4.

Methods of application of the six available members of this range of dyes (I.G.), giving shades fast to light and washing, and generally to perspiration, rubbing and sea water, are described. The dyeings are given their max. fastness by aftertreatment for 20–30 min. at 80–85° with solns. contg. 1–3% of $CuSO_4$ and 0.5–1.5% of 30% AcOH. (From *C. A.*, 1936, V. 30, Col. 3241.) (W)

BLEACHING: EFFECT OF pH ON THE RATE OF CHLORINE CONSUMPTION IN BLEACHING. W. O. Hisey and C. M. Koon. *Paper Trade J.*, Aug. 6, 1936, P. 36–43.

Gives the results obtained on bleaching sulphite pulp in buffered solutions of fixed pH. Electrometric titrations of bleaching liquors indicated that the pH of chlorine containing solutions was of great importance in determining the activity of the solution as an oxidizing agent. Throughout the pH range, the lower the pH, the more active the solution, as measured by the oxidation potential. Likewise, it was indicated that, for equivalent concentration of available chlorine, the composition of the liquor, with reference to the content of oxidizing forms of chlorine, namely hypochlorite ion, hypochlorous acid, and molecular chlorine, depends on the pH. (C)

CELLULOSE ACETATE RAYON: IMPROVEMENTS IN THE DYEING AND PRINTING OF. Jean Rolland. *Rev. gen. mat. color.*, 1936, V. 40, P. 65–77.

Discusses the application of aniline black dyeing to obtain as full effects as possible, treatment for selective printing and special effects. Tables show comparative results with different dyes. (From *C. A.*, 1936, V. 30, Col. 3239.) (W)

COLLORESIN DK IN THE PRINTING INDUSTRY. Max Kerth. *Mell. Textilber.*, 1935, V. 16, P. 794–5.

Colloresin is an alkyl cellulose ester. It cannot be used with other thickening agents such as starch and tragacanth. Heat (50–60°) throws colloresin out of soln. but it redissolves when cooled. Alkali and salts also ppt. it. It is used in the direct printing of vat and other dyes. (From *C. A.*, 1936, V. 30, Col. 3239.) (W)

COTTON CLOTH: INTERESTING ACETATE EFFECTS ON. R. Sansone. *Rayon & Mell.*, 1935, V. 16, P. 591–2.

Dyes are suggested and back padding procedures are described for producing fabrics in which the acetate pattern on the face contrasts strongly with the cotton ground. (From *C. A.*, 1936, V. 30, Col. 2762.) (W)

COTTON: SOFTENING ACTION OF VAT DYES ON. E. Meissner. *Deut. Wollen Gewerbe*, 1936, V. 68, P. 483–4; *C. A.*, 1936, V. 30, Col. 4011. (W)

DEGUMMING, WEIGHTING, BLEACHING AND DYEING OF SKEINED SILK. H. Feld. *Monatschr. Textile-Ind.*, 1935, V. 50, P. 293–4; *C. A.*, 1936, V. 30, Col. 2392. (W)

DESIZING WITH ENZYMES. A. Molnar. *Monatschr. Textil-Ind.*, 1936, V. 51, Fachheft I, P. 11–12; cf. *C. A.*, 1935, V. 29, Col. 3845; 1936, V. 30, Col. 4327. (W)

DISSOLUTION OF CHEMICALLY MODIFIED COTTON CELLULOSE IN ALKALINE SOLUTIONS. II. COMPARISON OF THE SOLVENT ACTION OF SOLUTIONS OF LITHIUM, SODIUM, POTASSIUM, AND TETRAMETHYLAMMONIUM HYDROXIDES. G. F. Davidson. *J. T. I.*, April 1936, P. T112–30. (C)

DRESSING OF SILK AND RAYON WITH AQUEOUS EMULSIONS. G. Baroni. *Boll. ufficiale staz. sper. seta*, 1934, V. 4, P. 28–32; *C. A.*, 1936, V. 30, Col. 2764. (W)

DYED TEXTILES: COMPARISON OF THE LIGHT-FASTNESS TYPES FOR—WHICH ARE IN USE AT PRESENT. P. Krais. *Angew. Chem.*, 1936, V. 49, P. 55–7; *C. A.*, 1936, V. 30, Col. 2010. (W)

DYEING AND SIZING OF STAPLE RAYON FIBRE. Georg Rudolph. *Kunstseide*, 1935, V. 17, P. 327–8, 421–3; *C. A.*, 1936, V. 30, Col. 2389, 2763. Review and discussion of dyes and sizes for rayon. (W)

DYEING OF SEMI-WOOL TOGETHER WITH ACETATE RAYON. Georg Rudolph. *Z. ges. Textil-Ind.*, 1936, V. 39, P. 213–15.

The temp. must be regulated carefully for good dyeing results. The color of the wool can be kept light by taking a smaller amt. of the acid or neutral wool dye. Detailed dyeing directions are given with formulas and a large no. of dyes are listed which are suitable for a variety of conditions and mixts. (From *C. A.*, 1936, V. 30, Col. 4011.) (W)

DYEING OF STAPLE RAYON COMBINED WITH WOOL. Walter Ryczynski. *Z. ges. Textil-Ind.*, 1936, V. 39, P. 137–8, 382–5; *C. A.*, 1936, V. 30, Col. 3651. (W)

ELIMINATION OF THE SOAP FROM DEGUMMED SILK. G. Baroni and G. Cola. *Boll. ufficiale staz. sper. seta*, 1935, V. 5, P. 53–6.

Acid soaps can be completely eliminated from degummed silk by treatment with alkali; it can be more easily removed by extn. with EtOH, or with boiling water followed by C_6H_6. (From *C. A.*, 1936, V. 30, Col. 2011.) (W)

ENZYME CHEMISTRY: PROGRESS IN. *Nature*, 1936, V. 137, P. 53–5; *J. Soc. Dyers Col.*, May 1936, P. 196. (C)

ENZYMES IN THE TEXTILE INDUSTRY: APPLICATION OF. Johannes Porzky. *Z. ges. Textil-Ind.*, 1936, V. 39, P. 198–9; *C. A.*, 1936, V. 30, Col. 3651. (W)

ENZYMIC WASHING OF TEXTILES. Fritz Ohl. *Kunstseide*, 1936, V. 18, P. 23–5.

The nature of enzymes and their use for scouring and removal of size from silk are discussed. Patented procedures are reviewed. (From *C. A.*, 1936, V. 30, Col. 2392.) (W)

FAST DIRECT COTTON DYES. Keija Oda. *J. Soc. Chem. Ind. Japan* 38, Suppl. binding, 1935, P. 658.

Primulin was diazotized in aq. soln. (ice-cooling) with $NaNO_2$ and HCl and the diazo compd. coupled with an acid hydroxyazo dye, *e.g.*, Orange II, in alk. soln. A direct red cotton dye was obtained, suitable for the dyeing of plant and animal fibres, and possessing light and acid fastness. (From *C. A.*, 1936, V. 30, Col. 2762.) (W)

FASTNESS OF WOOL DYEINGS TO WET TREATMENTS. II. F. L. Goodall. *J. Soc. Dyers Col.*, June 1936, P. 211–18.

Experimental evidence has been brought forward to indicate that the initial pH, previously stated to be pH 9.5, above which the tendency for all acid dyes to be removed from wool is greatly increased, should more properly be described as pH 8-8.2, and it is suggested that this effect is due to the alkaline swelling of the fibre known to become significant about this pH value. It has been shown that the nature of the extracting solution plays a very important part in the removal of dye from dyed wool by treatment with aqueous solutions; that aggregating or dispersing solutions produce respectively less or more removal of dye with colloidally dispersed dyes, in detailed accordance with the requirements of the present author's theory of application of such dyes; that the aggregating or dispersing nature of the solution is, on the other hand, relatively insignificant in the removal of molecularly dispersed dyes; and that reduction in content of inorganic salts in the extraction medium produces reduced removal with molecularly dispersed dyes and an increased removal with aggregated dyes, in accordance with Donnan Membrane Theory requirements in the former case, and with the present author's theory in the latter case. (C)

FIBRE-DAMAGING ACTION OF VAT DYES ON CELLULOSE. Hans Froitzheim. *Monatsh. Seide Kunstseide*, 1936, V. 41, P. 17–20, 22–4; *C. A.*, 1936, V. 30, Col. 2009. (W)

IV. RESEARCH METHODS AND APPARATUS

CALCIUM THIOCYANATE: USE OF—FOR THE DETERMINATION OF THE PROPORTIONS OF DIFFERENT TEXTILES IN MIXTURES IN THE PRESENCE OF OXY- AND HYDROCELLULOSE. K. Langer. *Monatsh. Seide Kunstseide*, 1936, V. 41, P. 284–6; *C. A.*, 1936, V. 30, Col. 6571. (W)

CHEMICAL REACTIONS FOR DISTINGUISHING VARIOUS FIBROUS MATERIALS. G. Scagliarini. *Giorn. biol. applicata ind. chim.*, 1933, V. 3, P. 97–100.

In the Lassaigne test wool gives reactions for CH^-, S^{--} and CNS^-, silk for CN^- and rayon for none of these. (From *C. A.*, 1936, V. 30, Col. 7348.) (W)

COPPER: DETERMINATION OF SMALL QUANTITIES OF—IN TEXTILE FIBRES ANE WEAVES. G. Durst. *Mell. Textilber.*, 1934, V. 15, P. 568; *Am. Dye. Rptr.*, Oct. 5, 1936, P. 556.

In a previous paper the author spoke of a method for the determination of small amounts of copper in textile goods, which related to a more exact control of the tendency, in the colorimetric method with ammonia, toward too high figures. He has since worked over the entire subject again. (C)

"GLEIFOMETER" YARN REGULARITY TESTER. A. Froning. *Leipz. Monatschr. Tex. Ind.*, 1936, V. 51, P. 141–3.

A description, with diagrams, is given of the Berthold "Gleifometer" (D.R.P. 597,282). The essential part of the apparatus is a pair of wheels between which the yarn passes. Each wheel is broken into three sectors, the rims of which have semi-circular grooves increasing in diameter towards the feed-point of the yarn. The three pairs of sectors are interchangeable to suit various counts and the tapering grooves secure that the yarn is "felt" at all diameters. The motion of the balanced sectors is transferred to a recording device, giving regularity traces. Typical records are reproduced. (C)

MEASUREMENT OF COLOR OF DYED TEXTILES. R. D. Nutting. *Tex. Rsch.*, Nov. 1936, P. 5–23; *Am. Dye. Rptr.*, Nov. 2, 1936, P. 585–92. (C)

MICRO-DETERMINATION OF COTTON FIBRE MATURITY IN POLARIZED LIGHT. E. R. Schwarz and G. H. Hotte. *Tex. Rsch.*, June 1935, P. 370–6; *Mell. Textilber.*, 1936, P. 549; *Rayon Tex. Mo.*, Nov. 1936, P. 86. (C)

MOISTURE CONTENT OF TEXTILES: RAPID METHOD OF DETERMINING THE. J. L. Spencer-Smith and J. A. Matthew. *J. T. I., Sept.* 1936, P. T219–28.

A method is described for determining the average moisture content in a fair size sample, *e.g.*, a whole hank of yarn; in this case, flax. The method is very simple and fairly rapid, employs only inexpensive apparatus and requires no heating or weighing. The apparatus and method of use is described and results are given illustrating the reliability and possible accuracy. The method is put forward as particularly suitable for routine mill use for various purposes and it is considered that the accuracy is sufficient for these purposes. (C)

MOISTURE TUBE: NEW. H. B. Alexander. *Rayon Tex. Mo.*, Nov. 1936, P. 53.

Although numerous devices utilize the principle of distillation with an immiscible solvent for the measurement of moisture in many classes of materials, the one described is new and posseses certain advantages. It is designed for use with a water-immiscible solvent, such as carbon tetrachloride, which has a greater density but a lower boiling point than water. It has been used during the last seven years in the Hercules Powder Co. laboratories for the routine determination of water in dynamite. (C)

OXIDATION OF WOOL. Milton Harris and Arthur Smith. *B. S. J. Rsch.*, Oct. 1936, P. 577–83; *Am. Dye. Rptr.*, Oct. 5, 1936, P. 542–5.

Oxidizing agents attack the disulfide groups of the cystine in wool and increase the solubility of the wool in alkaline solutions. The determi-

nation of the alkali-solubility may be used as a measure of the extent to which the wool is oxidized. The method is applicable as a control in practical processes, such as bleaching and chlorination, and offers a measure of the extent to which wool is degraded by photochemical reactions. Data are presented which indicate a relationship between the chemical and physical degradation of wool fibres. (C)

RAINPROOFED CLOTHS: TESTING OF. N. Cryer. *Tex. Mfr.*, Sept. 1936, P. 355–8.

Conclusions: (1) The weight and closeness of a chemically proofed fabric greatly affects its rain repelling qualities. (2) Within reason, it is better to have a light, closely woven texture than a heavier, but more loosely woven cloth for protection against rain. (3) The absorbency or otherwise of a raincoat lining largely influences the efficacy of the garment. By reason of its affinity for water, an uproofed lining causes a much greater amount of water to penetrate the outer cloth. Further, an unproofed lining readily soaks up the water that has penetrated the outer cloth. (C)

SECTION CUTTING BY A MODIFIED PLATE METHOD. J. M. Preston. *J. T. I.*, Aug. 1936, P. T216–8.

Modifications of the technique of the plate method of cutting fibre sections are described, which enable the method to be used for dark colored fibres and raw cotton hairs. (C)

UNIFORMITY: IMPORTANCE OF—IN THE CONSTANT RATE OF LOADING WITH THE SCOTT INCLINE PLANE SERIGRAPH. *Rayon Tex. Mo.*, Nov. 1936, P. 59–60. (C)

WATERPROOFING AGENTS: EVALUATION OF TEXTILE. I, II, III. Robert N. Wenzel. *Am. Dye. Rptr.*, 1936, Sept. 21, P. 505–14; Nov. 2, P. 598–601; *Ind. Eng. Chem.*, 1936, V. 28, P. 988–94. (C)

WOOL: MODERN DEVELOPMENT OF MICROSCOPIC TECHNIC AND ITS SIGNIFICANCE FOR THE TESTING OF. F. Schroder. *Deut. Wollen-Gewerbe*, 1936, V. 68, P. 1007–10.

A review describing modern methods of testing wool by new types of microscopes, devices for transmitted and reflected illumination, instruments for testing with polarized light, the Citophat, the Metaphot and others. (From *C. A.*, 1936, V. 30, Col. 6949.) (W)

V. ECONOMICS, PHYSICS AND MISCELLANY

PHYSICS IN TEXTILE RESEARCH. Dr. Irving J. Saxl. *Rayon Tex. Mo.*, Nov. 1936, P. 37–8.

Describes various instruments developed by the author and their use in exact methods of scientific analysis. (C)

STATISTICAL METHODS AS AN AID TO THE CONTROL OF QUALITY OF MATERIALS. Dean Harvey. *Rayon Tex. Mo.*, Nov. 1936, P. 71–2.

Paper presented at meeting of Committee D-13, A. S. T. M., Oct. 15, 1936. (C)

TEXTILE INDUSTRY INTERPRETS RESEARCH. I. NECESSITY FOR DEFINITION OF TERMS. II. SOME FUNDAMENTAL CONCEPTS OF TEXTILE PHYSICS. E. R. Schwarz. *Rayon Tex. Mo.*, Oct. 1936, P. 39–40; Nov., 35–6. (C)

SURFACE TENSION MEASUREMENT APPARATUS. L. D. Mahajan. *J. Sci. Instru.*, 1936, V. 13, P. 189–91.

An apparatus is described for the accurate and rapid determination of surface tension, density, and parachor of both mobile and viscous liquids which are available in small quantities. It combines the Warren manometric system with a Sutton capillary tube. Results obtained with it are compared with those obtained by other types of apparatus. (C)

(*Continued from page 132*)

Mr. Ross: You realize that on coated paper they are coating color on. We haven't experienced that, except with some ingredients. Of course, every coating mill has its own pet formula. There are some ingredients that they claim we cannot carry it very far with, but we haven't found any with which we cannot do it instantaneously; I mean at the very beginning of the process, for a short time. I rather think that that has been worked out in the automobile industry. We haven't had that in the paper industry.

Mr. Fonda: I was thinking particularly of pure whites.

Mr. Ross: We do get it on whites, but not in the first process of just heating up. In fact, the paper doesn't seem to reach any temperature at all to begin with. It is hard to distinguish how much it has increased in temperature when you get through. You have really only started. But would that have effect on colors of paints and similar things, or wouldn't it? That really wouldn't answer your question, would it?

Mr. Fonda: No; I am interested in pure whites.

Chm. Smith: I think that probably goes back again to the fact that as long as you have water there, and your paper or your textile temperature isn't very high, you won't get a browning, but if your water goes out you will get discoloration and other kinds of damage at the same time. And that is the point you make: that these high temperatures are only used at those stages where there is plenty of water, so that your material temperature never gets very high.

Mr. Ross: No, we haven't had that.

Mr. Fonda: Another gentleman mentioned a figure of around 35%. If you are up over that, do you think you are safe on color, say, a wet bulb of 115°?

Mr. Buck: If it was in the grey it wouldn't have any effect at all, but if you use colors I think you will get some discoloration. I happen to know that on certain greens, browns, and rusts, on crepe goods, too high a temperature will cause discoloration. I don't know just where it takes place, but, at some stage between entering and leaving the dryer, high temperatures will cause slight darkening of certain colors. Other colors are not affected at all. But in the grey, if you don't apply any color to the material, I don't think it would have any effect, so long as there is sufficient water.

Chm. Smith: I think probably the dye chemist could tell us something about that. There are probably certain dyes that are sensitive to heat.

Mr. Buck: I think that is what it would be.